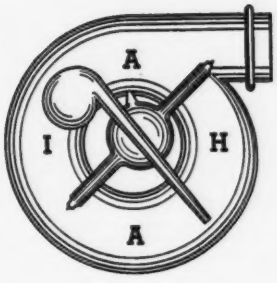
UNIVERSITY
OF MICHIGAN
JUN 20 1952
PUBLIC HEALTH
LIBRARY

AMERICAN

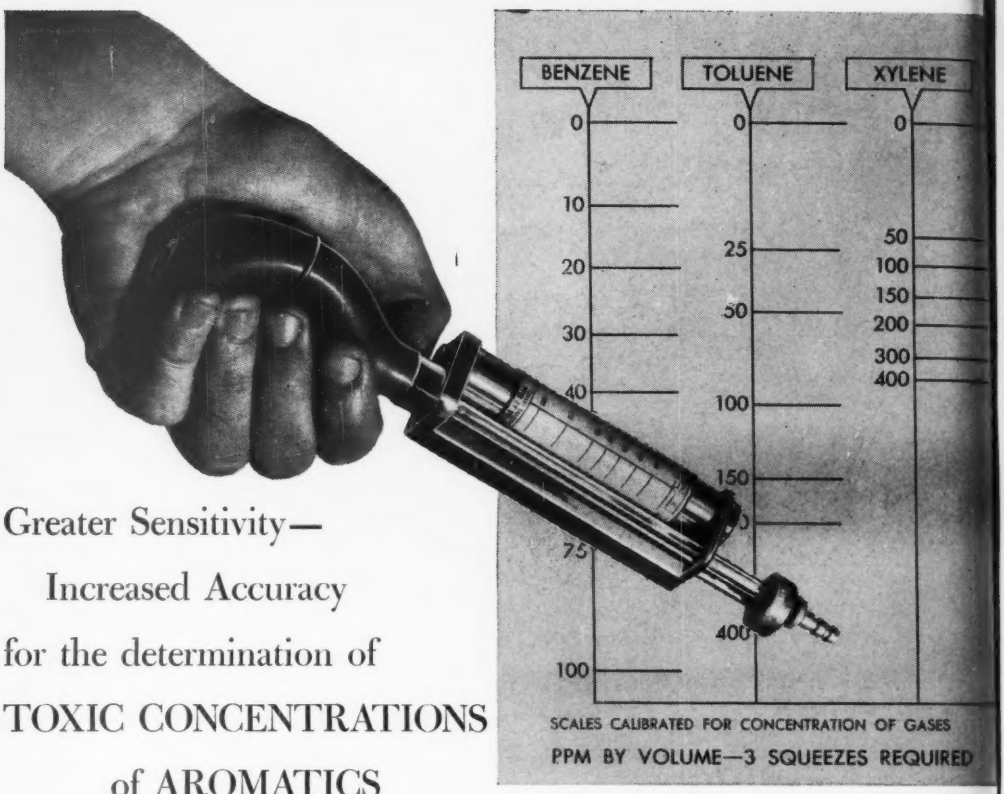
INDUSTRIAL HYGIENE

ASSOCIATION

QUARTERLY



VOLUME 13 JUNE, 1952 NUMBER 2



Greater Sensitivity— Increased Accuracy for the determination of TOXIC CONCENTRATIONS of AROMATICS

. . . the New M. S. A. AROMATIC HYDROCARBON DETECTOR

With maximum allowable concentrations for 8-hour per day exposure to benzene set at 35 ppm, and 200 ppm for both toluene and xylene, it is essential to know when these "safe limits*" are exceeded if workers exposed to these hazards are to be properly safeguarded.

To help keep an accurate, constant check on these aromatic concentrations, the M.S.A. Research Laboratory perfected this Detector based on the method described by Hubbard and Silverman in this publication in July 1950, Vol. 2, No. 1.

An important factor contributing to the greater sensitivity of this instrument is the technique employed in preparing the detector tubes. The ingredients for the tubes are *mixed in the field.* This "fresh mix" method assures the highest stability of indicating material.

To obtain greater accuracy in reading, a length of stain is developed that increases with the increasing concentrations of aromatics. Concentrations are easily and quickly determined on the cylindrical scale which is graduated separately for benzene, toluene and xylene. The original fill in the tubes is white, changing to brown after exposure.

Complete details on this easy-to-use, compact device are described in Bulletin No. DD-1. Write for your copy.

**Threshold limits adopted by the American Congress of Government Hygienists.*

Call the M.S.A. Man on your every safety problem . . . his job is to help you.

MSA
SAFETY EQUIPMENT HEADQUARTERS

MINE SAFETY APPLIANCES COMPANY
BRADDOCK, THOMAS & MEADE STREETS
PITTSBURGH 8, PA.
At Your Service: 66 Branch Offices in the United States
MINE SAFETY APPLIANCES CO. OF CANADA LIMITED
Toronto, Montreal, Calgary, Winnipeg, Vancouver, New Glasgow, N.S.
Representatives in Principal Cities in Mexico, Central and South America
Cable Address: "Minsaf" Pittsburgh

AMERICAN

INDUSTRIAL HYGIENE

ASSOCIATION

QUARTERLY

Volume 13 JUNE, 1952 Number 2

CONTENTS

Air Pollution Abatement by the Chemical Industry ..... J. M. Gillet 59

Pulmonary and Metabolic Disturbances in Persons Exposed Industrially to Beryllium—An Abstract ..... Dr. Joe W. Howland 61

A Rational Approach to Air Pollution Legislation ..... George E. Best 62

Report of the Local Sections Committee 69

Public Health and Air Pollution ..... John H. Foulger, Ph.D., M.D. 70

Some Factors for Air Pollution Control—An Abstract ..... H. G. Dyktor 74

Activities of AIHA American Association for the Advancement of Science ..... F. A. Patty 75

Wind Tunnel Techniques Used to Study Influence of Building Configuration on Stack Gas Dispersal ..... Gordon H. Strom, Ph.D. 76

Anticipating and Preparing Against Possible Industrial Hazards from Air Pollution ..... George R. Hill 81

Area Air Pollution Problems and the Individual Plant ..... Hamnett P. Munger 88

The Development of Industrial Hygiene and Safety ..... Leonard Greenburg, M.D. 95

Industrial Hygiene Briefs 105

Books 106

American Industrial Hygiene Association
A Report of the Thirteenth Annual Meeting 107

The President's Page ..... William R. Bradley 108

The Report of Temporary Committee on Lantern Slides 109

News of the Local Sections 110

Officers and Committees 111

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION QUARTERLY, published by the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION in March, June, September, and December. HERBERT J. WEBER, Editor; HERBERT T. WALWORTH, Associate Editor; VINCENT J. CASTROP, Advertising Editor; WILLIAM T. McCORMICK, Circulation Editor; A. D. CLOUD, Publisher; DORIS FLOURNOY, Editorial Assistant. Publication, and Editorial Offices, 605 North Michigan Avenue, Chicago 11, Illinois. Subscription $2.00 per year in the United States; $2.50 per year in Canada; $3.00 per year in other countries. Single copies 75 cents. Copyright, 1952, The American Industrial Hygiene Association.

Entered as second class matter May 3, 1948, at the post office at Sheboygan, Wis., under the Act of March 3, 1879.

"SAFE" SAFETY SOLVENTS

with High Flash Point and Low Toxicity

FO 128
FAST DRYING LIQUID

No residue on drying. To be used for cleaning electrical and mechanical equipment with complete safety to components.

ORDER TRIAL 53 Gal. Drum at $1.44 per gal.

FO 101
SLOW DRYING LIQUID

Exceptionally safe for spray-cleaning of equipment parts, electric motor stators and rotors and for tank-soaking of metal parts. May be recovered by filtration and reused.

ORDER TRIAL 53 Gal. Drum at $1.10 per gal.

ABOUT TOXICITY

The toxicity of Carbon Tetrachloride results from one of two factors, or both:

A. Decomposition of Carbon Tetrachloride in the presence of heat and iron, the by-product of which is phosgene.

B. Hydrolysis of Carbon Tetrachloride resulting in hydrochloric acids.

In the first instance the lungs are affected, and in the second, permanent damage occurs to the liver.

In compounding FO-101 and FO-128, we have taken into consideration not only the maximum allowable concentration of the various chlorinated solvents, but their vapor pressure as well, since each must be considered in direct relationship to the other.

The maximum allowable concentration and vapor pressure of the materials in "FO" products, as compared with the Carbon Tetrachloride, are as follows:

	M.A.C.*	V.P. at 25°C
Carbon Tetrachloride	35 PPM	115.0
Percentage of Chlorinated Solvent in FO-128	100 PPM	18.0
Percentage of Chlorinated Solvent in FO-101	50 PPM	1.8

*American Conference of Government Industrial Hygienists, 1951.

Toxicity is determined not only by the maximum allowable concentration, but the rate at which it is reached; the latter is governed by the vapor pressure, and therefore the safety quotient, as defined below, should be considered as a guiding factor.

In considering the toxicity of a material, in the light of the table given above, the quotient resulting from the maximum allowable concentration divided by the vapor pressure, should be the guiding factor. In other words, this safety quotient for Carbon Tetrachloride is 0.3, for the percentage of chlorinated solvent in FO-128 it is 5.6, and for the percentage of chlorinated solvent in FO-101, it is 57.8. Therefore, the percentage of chlorinated solvent in FO-128 appears to be eighteen times as safe as Carbon Tetrachloride, and the percentage of chlorinated solvent in FO-101 ninety-two times as safe as Carbon Tetrachloride.

In comparing our solvents with Carbon Tetrachloride, consideration should be given to the fact that our solvents are composed only in part of chlorinated materials. Hence, comparisons should be made on the basis of volume of whole product (ours) vs. 100% Carbon Tetrachloride. You will also note that the vapor pressure of Carbon Tetrachloride at room and summer temperature is considerably higher than that of the chlorinated solvents percentage in FO-101 and FO-128, yet its PPM in allowable concentration is much lower.

Toxicity is minimized because of the lower initial concentration and lower vapor pressure that will not reach the M.A.C. as quickly as Carbon Tetrachloride, hence our products are appreciably safer to use. This safety is enhanced by our selection of auxiliary solvents on the basis that the percentage of chlorinated solvent remains fairly constant throughout the evaporation cycle, thus assuring uniformity in effectiveness and safety of handling.

• • • • • •

Write Dept. IM for
INDUSTRIAL MAINTENANCE BULLETIN B3 or
AVIATION MAINTENANCE BULLETIN A3

AVIATION — INDUSTRIAL DIV.
FINE ORGANICS Inc.
211 East 19th Street, New York 3, N. Y.

FINE ORGANICS
F.O
AVIATION CHEM

AMERICAN
INDUSTRIAL HYGIENE
ASSOCIATION
QUARTERLY

Volume 13 JUNE, 1952 Number 2

Air Pollution Abatement by the Chemical Industry
— Review and Survey —

J. M. GILLET

A GREAT DEAL of our discussion at this conference will center on avoidance of air pollution. If there were no pollution to start with, there would need to be no abatement, and our committee would have to change its name. We shall talk about what can be done before a plant is placed in operation or even built, to insure that the air that may pass through, over, or around it, will still be acceptable as the atmosphere in which our neighbors, our employees, our customers, and our shareholders can live in health, comfort, and contentment.

Evidence of the importance our industry attaches to pollution avoidance came to light recently when the board of directors of a large chemical company denied authorization to its management to start construction of a multi-million dollar project because the provisions made for suppressing fume effluents were, in their opinion, inadequate. This shows the trend in the chemical industry; processes are so designed as to reduce to a minimum the exhausting to the air of odors, fumes, and gases, and then there are provided scrubbers, absorbers, furnaces, or precipitators to reduce these effluents to an unobjectionable quantity.

The Air Pollution Abatement Manual, which is being assembled under the sponsorship of this committee, is intended to make available to industry as a whole, a large quantity of information on acceptable limits for impurities, methods of analysis, the capabilities of different kinds of equipment to do various jobs, a comprehensive bibliography, and comments on how to work with the plant community to promote mutual good will and confidence.

The main objective in these air pollution studies is how to get acceptably clean air in the community at the least cost—for it does require spending large sums of money. This committee attempted a survey last year to see what our industry is spending to keep the air clean in its plant areas. Because so much of the cost is inseparable from the cost of the processing equipment and the manufacturing operations themselves, it was hard to get an accurate measure of what is being spent, but from the data reported by our member companies on plants where an accurate segregation of these costs was possible, it would appear that during the years 1946 through 1950, upward of $35,000,000 was spent on abatement equipment, and that the annual cost of operating these abatement facilities is about $9,000,000.

The cost of keeping the air clean concerns not only the manufacturer, but also the public at large, for eventually the cost is unavoidably paid by the public. If the cost is added to the manufacturer's selling price, the purchasers of the goods pay it directly; if it is taken out of industry's profits, the tax collector is the principal loser. The government takes most of the corporations' profits before the owners even

Presented at Seventh Air Pollution Abatement Conference, Manufacturing Chemists' Association, Hotel Statler, New York City, February 25 and 26, 1952.

get a look at them. What the government leaves the industry to pay out as dividends, is again taxed as income to the shareholders. Thus a reduction in company profits means a reduction in tax revenue to the government, which must be made up by raising the tax rates on all tax payers.

Industry can be reasonably expected to keep pollution from its plants to a level that will avoid injury to health and financial loss to its neighbors, and to go even further in trying to avoid any discomfort or offense to the esthetic senses of the community; a point can be reached, however, beyond which further polishing up of the air becomes exceedingly costly; the community must then decide whether it can afford this extra luxury.

Atmospheric pollution in this country has shown a marked decrease in many areas, and in the country as a whole. Part of this improvement has come about through better engineering knowledge and improved process design, part of it through an increasing awareness of responsibility. Pressure of public opinion on both industry and the private citizens has had its effect, while in some of our larger cities, legal compulsion backed by sound public opinion, has been the effective force.

The MCA believes that in principle, self-regulation is the most desirable and least wasteful method of achieving clean air, or any other desired goal, although it may be slow. Self-regulation has been well called the keystone of a free society. It has been unpopular, however, during the past thirty years, which have seen the rise of big government in this country, socialism in Britain, and Fascism and Communism in Europe and Asia. In all of these areas government controls over many phases of human activity have been substituted for individual responsibility.

I do not imply that government does not have a legitimate role to play in air pollution abatement, for it is often desirable to delegate leadership to agents of government, to focus and coordinate the community's effort to improve atmospheric conditions. Many cities and districts have pollution abatement agencies established by law and presided over by highly qualified administrators. It is particularly pleasing to us to have as our guests today so many outstanding pollution control and public health officials. We honor them for their notable achievements, and their intelligent approach to the problems involved. Their leadership has achieved much, even in many areas where the laws under which they operate are not too happily conceived. A study of much of the legislation creating pollution control authority shows that many laws contain features that are good and some that are in themselves bad. It is greatly to the credit of our officials that these laws have been so intelligently and patriotically administered as to avoid the evil consequences that could have resulted from some of these objectionable provisions.

Laws that curtail the liberties and invade the rights of a free people are evil, even though they may be excused on the plea that such curtailment is necessary to protect the public from an irresponsible fringe. It should be remembered that in all history no free society ever capitulated to a dictator who admitted his lust for power; the freedom of Rome was lost as was that of Germany and Italy in our own time to those who were granted more and more control over the people for the ostensible purpose of protecting them. Even in this country the late President Franklin D. Roosevelt campaigned for re-election in 1940 on the plea that during his first two administrations, laws had been enacted which if administered by a less benevolent executive, could be used to shackle the American people.

In drafting legal measures for effecting the abatement of air pollution, the basic principles of a free society should be ever kept in mind, and equitable treatment should be accorded to all components of the affected areas. It is difficult to persuade a manufacturer, for instance, that in these days when capital is scarce and costs are high, he should make big expenditures to keep his tall stack from smoking, while within a half-mile radius of his plant, five hundred house-holders are burning rubbish in their alleys and low grade fuel in their heating plants, while their wives cook onions and fry fish in rancid fat.

Our MCA committee has spent three years studying legislative proposals relating to air pollution abatement. For the

first year the argument raged as to whether an attempt should be made to frame a so-called model law. It wasn't too hard to see that no model was likely to fit more than one situation, and the idea was abandoned.

We did, however, come to a realization that there were certain fundamental principles which are applicable to any area situation and which if used as a guide in framing legislation would avoid the most serious evils that have crept into some past legislation. These fundamentals will be discussed here this morning. We know there are differences of opinion on some of these factors, partly through a misunderstanding of what is intended, and partly as a result of different points of view. We shall welcome an airing of these differences and hope we may end up with a better understanding of the problem and of our respective beliefs.

Pulmonary and Metabolic Disturbances in Persons Exposed Industrially to Beryllium

DR. JOE W. HOWLAND
Professor of Radiation Biology and Chief of Division
Atomic Energy Project, The University of Rochester, School of Medicine and Dentistry

ABSTRACT: A review of the clinical signs and symptoms of pulmonary granulomatosis of beryllium workers (berylliosis) shows that progressive weight loss and dyspnea (in the order named) are the most consistent early findings associated with the disease. All laboratory procedures parallel the expected physiologic changes and are not pathognomonic. Excretion of beryllium in urine indicates previous exposure only. This is also apparently true of beryllium content of pulmonary tissue.

Studies of the respiratory physiology of 10 patients on a carefully controlled metabolic regime indicate that a marked variability occurs. A large factor may be the presence of emphysema as a part of the process. A distinct increase in the arterio alveolar gradient measured as pO_2 parallels the severity of the process. Use of oxygen raises the pO_2 in severe cases to normal levels.

Metabolic study of these patients shows a defect in their ability to store protein in the tissues. Poor absorption of protein is shown in the presence of a high fecal nitrogen. Some abnormalities of the serum protein are shown by electrophoretic analysis. Speculation on the nature of these metabolic changes was engaged in. The dissimilarity between the observed changes and those of pulmonary fibrosis suggests that they are not secondary to anoxia.

Discussion of therapeutic procedures was carried out. Current opinion as to the nature of ACTH and cortisone effects indicates that improvement may be less striking than originally reported, and that these materials only reduce the rapidity of the process. Use of dietary measures and oxygen depends on the clinical status of the patient.

Presented at a joint meeting of the Upper and Western New York Sections of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION Saturday, December 1, 1951, at the University of Rochester School of Medicine and Dentistry.

A Rational Approach to Air Pollution Legislation

GEORGE E. BEST
Mutual Chemical Corporation of America

Purpose

PROMPTED by a growing awareness of responsibility for conserving natural resources and for being good neighbors in community life, the chemical manufacturing industry has been paying increasing attention to controlling pollution of the air. Aware also of sentiment in some quarters favoring legislated control, and of the potentially unhappy consequences of an improper law, the industry selected a committee to develop the basis for a fair and workable law. The purpose in preparing this statement of sound legislation principles is not to cast an opinion for or against air pollution control legislation, but to create the framework within which a proper bill can be written if it is determined that a control law is wanted.

Introduction

UNTIL COMPARATIVELY recent times atmospheric pollution was regarded as an index of America's prosperity and growth. Prospects were good where the factory chimneys smoked. That idea is rapidly becoming obsolete. More and more people are realizing that unlimited release of waste products into the air may have undesirable effects. This was called sharply to nationwide attention by the fatalities at Donora in 1948, and has been kept in the public mind by the publicity given to the annoying Los Angeles smog.

When people are troubled, their reaction often is: "There ought to be a law...." Unfortunately, they are sometimes stirred up to demand one by crusaders who inject fear into their minds. So it is with air pollution. There have been stark headlines about potential tragedies far worse than Donora in localities where the likelihood of such an occurrence is vanishingly small. Let's put the Donora incident in proper perspective by remembering that industrial operations had been going on with little change in that community for many years without a prior occurrence. Moreover, in spite of highly concentrated air-polluting operations in many localities, there has never been a similar occurrence elsewhere in this country.

Clearly air pollution is not a serious or critical menace to public health.[1] Longevity is steadily increasing along with expanding industrialization. Scientific proof of relationship between air contaminants and damage to health has been exceedingly elusive in spite of extensive research. People generally are not justified in fearing that their health is endangered by air pollution. However, there is no doubt that cleaner air would make our industrial communities pleasanter places in which to live.

Inasmuch as health is not a dominating factor, are there other considerations that might stimulate a community to consider a law to curb air pollution? Yes, it cannot be denied that in some localities air pollution is a nuisance—a very real one. Smoke and other varieties of suspended matter soil laundry, wall paper, curtains, parked automobiles, etc., and certain odors are generally objectionable. Less likely or frequent are instances of direct property damage, such as premature failure of house paint or damage to vegetation or livestock. Where these effects are offensive and those responsible for them do not recognize the trend of the times and decrease pollution to acceptable levels, control legislation may be justified.

But before passing a law, let's be sure on two counts. First, is a new law needed? Here's the way one author puts it: "... Our efforts must be directed just as much to full utilization of existing legislation as towards the drafting of new laws. Only where the lack of legislation is a real impediment to effective air pollution control need we concentrate on new legislation."[2] Second, if a new law appears to be in order, let's make sure it's a good one—one that will accomplish its purpose most efficiently without being unfairly or unnecessarily re-

Presented at Seventh Air Pollution Abatement Conference, Manufacturing Chemists' Association, Hotel Statler, New York City, February 25 and 26, 1952.

strictive. Also, there's that little matter of footing the bill, which inevitably is passed on to the public. The following words of wisdom were written with reference to smoke ordinances, but apply equally well to all aspects of air pollution control: "... all differences of opinion and all controversy relative to a 'smoke' ordinance are basically economic. The necessary compromises and agreements could be more readily reached if this were constantly kept in mind. It can be assumed that no one desires unclean air; the question is, how clean an air can the community afford? Engineering can provide it. For example, all heat and power needed could be produced electrically at one plant and then distributed electrically; the gases from this plant could be washed and purified. Steam could be distributed from one plant. Fuel could be gasified at one plant and distributed by pipe lines throughout the community. Such centralized schemes have long been adopted by many communities, as far as water and sewage are concerned, but are not ordinarily considered for the purpose of obtaining pure and healthful air because of the cost. What is considered is some economic compromise. The success and life of the ordinance depend upon the sagacity of this compromise."[3]

With these thoughts in mind, let's try to develop sound basic principles for a law on air pollution control.

Part I—Fundamental Precepts

Air—A Useful Natural Resource

SINCE THE BEGINNING of life on this planet the atmosphere has functioned as an acceptor of emitted wastes. Breathing creatures inhale oxygen and exhale carbon dioxide, which is transferred through the air to green vegetation where the oxygen is released to complete the cycle. As industrial activities developed, there was no reason to question releasing waste products into the air—not until the amount became "too much."

The objective of air pollution control should be to limit the amount of foreign material in the air so that there will not be "too much," but at the same time allow the atmosphere to function usefully to its fullest capacity. This principle was recognized in a recent Oregon bill[4] which provided for "reasonable or natural use" of the air. It is logical to regard the atmosphere as one of many natural resources which are being and should be used to technical and economic advantage. Today modern industry is paying more and more attention to atmospheric conditions in considering new plant sites, and seeking the services of meteorologists in addition to chemists and engineers to aid in planning for satisfactory operation.

Atmospheric Capacity

THE QUESTION then becomes: How much is "too much?" The answer depends on the nature of the air-polluting material, the specific effects it produces, and where it is emitted. The release of potent-smelling fertilizer dust would produce a different reaction among city dwellers who would dislike it, than among country folk who would appreciate its beneficial effect upon their land.

Thus a proper appraisal of air pollution should be based on the undesirable effects of pollution in specific locations rather than its mere presence.

Definition of Pollution Area

OBVIOUSLY air currents do not respect municipal, country or state lines, although the influence of any single air pollution source or group of sources is fundamentally local in character. Thus a localized pollution area may be defined as one affected by the same sources of air pollution.

Observance of political boundaries complicates dealing with air pollution control. Yet from a practical standpoint, they cannot be wholly ignored. What is believed to be the best compromise is outlined in a section to follow.

Concept of Uniqueness

EACH LOCALIZED air pollution area is unique unto itself. Atmospheric dispersion of air-borne wastes depends upon air movements and topography. The waste load capacity of a given area is influenced also by the height and relative location of the various points of emission. Obviously a heavy concentration of low stacks in a narrow valley would be more likely to cre-

ate an undesirable situation than would scattered tall stacks in open country, assuming the same rate and kinds of emissions and comparable surroundings as to habitation, use of property, etc.

Superficial consideration of the air pollution problem occasionally leads people to the fallacious view that the remedy is to establish concentration limits for each air contaminant at the source of emission, and apply them uniformly throughout the state or nation. This is wrong, both technically and economically, for it would require everyone to meet the restrictions required for the worst situation. Further, concentration values alone are almost meaningless. They become significant only when used in conjunction with such factors as rate of emission, stack height, and wind velocity.

It is proper to judge air pollution only on the basis of relating air conditions at the point of contact (e.g., ground level) to effects produced by them. As technical knowledge about air pollution increases, it may become established that a certain limit of dust fall represents the tolerable level in city areas or that a certain limit of sulfur dioxide is all that specific crops can stand, etc. Information of this sort emphasizes the fundamental validity of the concept of uniqueness.

Limitations of Technical Understanding

GREAT STRIDES have been made in the engineering aspects of air pollution control. Facilities have been devised for eliminating, to some degree at least, a large proportion of potential pollutants from waste effluents. New developments continue, directed toward solving the remaining problems and lowering the cost of treatment.

Nevertheless there remain many unsolved problems. An outstanding example is the Los Angeles smog. Several million dollars have been spent to date in attempting to determine the cause of eye irritation, which is the basic complaint about the smog. Valuable information has been obtained from this research, but the smog components responsible for eye irritation have not yet been clearly established.

Comparatively little is known about the effects of air pollution on animal or plant life or on property, but research aimed in this direction is gradually lifting the veil of ignorance. In the meantime it is illogical to impose arbitrary or uniform restrictions. Administrators of air pollution control should be alert to apply significant information as it becomes available, but always should keep their activities within the bounds of technical understanding.

The Los Angeles situation should be a stern warning in this respect. By law the machinery for air pollution control was created and set in motion. Before knowing the reason for the smog's undesirable effects, arbitrary rules and regulations were decreed. In less than two years 12 million dollars were spent within Los Angeles county for the reduction and control of air pollution—all without knowing what to correct! It is not surprising that even this large sum did not effect a cure.

Right of Local Option

THE REPORT of a recent survey of stream pollution control activities contains the following:[5]

"The principle was expressed by practically all governmental authorities that where a stream is polluted by an industry upon which the life of a community depends, it is better to permit some degree of pollution and maintain the community, than to abate the pollution and destroy the community. This principle was more picturesquely expressed by one of the general public . . . when . . . asked if the deathly stench from a nearby pulpmill was not unbearable. 'Yes' was the reply, 'but it's less unbearable than the deathly stench from a dead town'."

This principle is equally appropriate in the realm of air pollution. If it can be demonstrated that reduction of pollution to an innocuous level is not economically feasible, the people whose livelihood would be affected should have a voice in deciding the outcome.

Responsibility

REGARDLESS of the mechanism by which air pollution control is administered, the ultimate responsibility for limiting the release of pollutants to tolerable quantities must rest with the operators of the units from which the pollution comes. However in some instances, as in California, there

has been reluctance to give industry latitude in discharging this responsibility. A reflection of this attitude is the permit system, which in effect licenses limited pollution, entailing approval of complete design plans, operation under temporary variance permits, issuance of final permits, and other time- and money-consuming features, burdensome to both administrators and operators, and wholly unnecessary.

One recent article by public officials pleads that "No administrative agency is so well staffed that it can feret out each new pollution source by field observations alone," and indicates the need for a system that will "put the administrative agency on official note of each new pollution source."[6] This is a reasonable position to take, and a plan discussed in a section to follow indicates how this can be done with minimum effort and yet leave the responsibility for proper control of emissions where it belongs, squarely on the shoulders of the operator.

Statement of Law in Principle

IN BRIEF the fundamental basis for an air pollution law might be characterized as follows:

Pollution of the atmosphere to the detriment of health or property shall be unlawful. This shall not be construed as contrary to the reasonable or natural use of air for dispersing waste products within the proper capacity to do so. Each localized area, i.e., affected by the same sources of pollution, shall be considered unique, and pollution within the area judged on the basis of its specific effects. The requirements for pollution reduction and control shall remain within the bounds of scientific knowledge and economic feasibility. The responsibility for proper control of emissions shall lie with the potential offender. Where community livelihood would be adversely affected by drastic reduction of air pollution, the right of local option is to be exercised in determining the extent to which reduction of pollution shall be required.

Part II—Organization

IN KEEPING with the foregoing fundamentals, legislation for the reduction and control of air pollution can best be achieved by embodying the following seven cardinal principles:

1. Creation of a state bureau staffed with technical personnel.
2. Establishment of localized air pollution zones.
3. Appointment of local air pollution control commissions of representative community people for each local pollution zone.
4. Registration of points of emission.
5. Granting reasonable rights of entry to private property.
6. Action by the state bureau with the consent of the local control commissions to first recommend and then through the courts enforce specific requirements to achieve a particular objective.
7. Cooperation in technical advancement through the state bureau.

Creation of a State Bureau

AIR POLLUTION is strictly a localized problem, unique to the particular locality and to the economy of the community. However, in view of its technical complexity, the cost of adequate physical facilities for dealing with it from an investigative point of view is so great that these facilities would be prohibitively expensive for all but a few heavily populated centers. It has been estimated that a population of at least 100,000 is necessary to support a minimum air pollution control unit.[2] Therefore as a matter of principle it is impractical to consider establishing independent air pollution control administrations exclusively at the local level. It follows logically that the proper place to establish technical facilities for measuring air pollution and appraising its effects is within an agency of the state government. The unit so constituted, hereinafter referred to as the state bureau, would consist largely of technical personnel. The administrative director of the state bureau should have the qualifications of a professional engineer whether or not the office is appointive. To effectuate the results of the bureau's activities the services of an executive secretary, preferably a lawyer, would be helpful. Technical staffs of large cities could augment the efforts of the state bureau where these municipalities might constitute or be included in localized air pollution zones.

Usually localized pollution areas will include parts of more than one municipality or county. State investigative authority avoids the complications of dealing with different political entities within a given area. In some instances a pollution area may include portions of two or more states; thus an adequate law should provide for cooperation with other states, or even other countries, in dealing with mutual problems.

The proper location of the state bureau within the state government is best left to individual states to decide. In some cases it may be preferable to place these responsibilities in an existing department, whereas in others it may be better to establish a separate bureau.

Establishment of Localized Zones

AS ALREADY indicated, air pollution problems are unique to each locality, depending upon the character and the amount of emitted material and the presence and relative location of subjects, both animate and inanimate, which can be affected by the emissions. Accordingly a localized air pollution area should comprise an area where there is a reasonable sameness of the problem, i.e. an area affected by emissions from essentially the same sources.

An air pollution zone should be established by the state bureau only where careful study and survey show air pollution in the area is excessive in the sense previously discussed, and where it is recognized by the residents as constituting a problem needing attention and action. To guard against arbitrary action, public hearings should be held regarding the propriety of establishing the proposed zone so that people in all segments of the area that might be affected can make their feelings known. The decision of the state bureau could be made subject to confirmation by a direct referendum if desirable. Once established, the boundaries of a zone should not necessarily remain permanent, and the state bureau should keep alert to changing conditions in and near the zone.

Appointment of Local Control Commissions

TO HELP THE STATE bureau preserve the unique character of each air pollution zone and to better serve local interests effectively, an air pollution control commission should be appointed within each zone so established. The commission, appointed by the governor or as otherwise provided, should represent a fair cross-section of the interests in the zone. It is suggested that the commission consist of seven men as follows:

a. A municipal official
b. A county official
c. A public health official
} representing the public

d. A representative of local agricultural interests.
e. A public utilities representative.
f. A representative of industry—an executive.
g. A representative of industry—a technical man, such as a professional engineer.

All members of the commission should either live in the zone or be directly affiliated with interests in the zone; it probably would be helpful if at least one of these seven men is a lawyer. The administrative director and the executive secretary of the state bureau should be non-voting ex officio members of each commission established in the state, with the executive secretary serving as secretary for each commission for the purpose of integrating the records.

Presumably commission members should serve without pay but receive expenses. Their terms of office should be staggered to permit change in personnel but assure continuity of action.

The primary duties of the control commission should be to correlate the technical services of the state bureau with the viewpoint and needs of the pollution zone. When specific recommendations for decreasing excessive emissions are in preparation by the state bureau, as discussed in a section to follow, the commission should advise the state bureau regarding the effect of these recommendations on the interests and economy of the zone. The commission should be empowered to validate by majority opinion recommendations which are in the overall best interest of the zone, or to invalidate, similarly, recommendations failing to meet this qualification. Once validated, recommendations should take the form of directives for corrective action. An important function of the commission should be to work with the operators involved in order that compliance would be

achieved with maximum promptness and minimum cost.

The commission should hold public hearings on major problems so that the state bureau can be better informed of local sentiment. The commission should by all means keep the communities within the zone fully advised of progress so that local people and industry can better appreciate the objectives and activities of the state bureau.

Registration of Points of Emission

INTELLIGENT PROMOTION of remedial measures for air pollution control must be based on recognition of specific undesirable effects and their causes. In order to act effectively, the state bureau must be informed about waste emissions to the air throughout the state. This can be accomplished most efficiently by requiring that each point of emission be registered with the bureau. The data called for should include (a) location, (b) size of outlet, (c) height of outlet, (d) rate of emission, (e) composition of effluent.

Registration should be made on a statewide basis to aid the state bureau in defining localized air pollution zones, and to facilitate correlating undesirable effects with the sources of pollution that are responsible. There should be certain exemptions from registration, such as single nonrecurring emissions, accidental discharges, safety vents, small units, etc., the details of which are probably best left to the state bureau.

As a precaution against obsolescence of registered data, it should be incumbent upon each operator to re-register as often as necessary to keep the registered data representative of current operating performance.

Expected emissions from new installations should be registered as far in advance of operation as feasible, e.g., upon completion of design. This requirement is logical as a curb on excessive emissions before they occur—prevention is better than cure—by insuring due consideration of air pollution control in planning new installations. If the expected emissions appear excessive to the state bureau, the bureau should issue a warning to this effect. Such a warning, on record also with the local air pollution control commission, would be a strong deterrent to proceeding without being certain of adequate provision for air pollution control. If the operator remained convinced that his emissions would not be harmful, however, coercion should not be applicable until actual proof of harmful effect is established. Registration of actual emissions should be required as soon as representative operating data can be obtained.

This plan is superior in every respect to a permit or licensing system. It provides the state bureau with the information needed without the trouble of reviewing plans, processing applications and issuing permits, the time and talent for which can be much more fruitfully spent in seeking solutions to problems revealed by the registered information. At the same time the operator has maximum freedom of action in meeting the problem, and is not called upon to reveal extraneous information about raw materials, processes, equipment or products that are often secret.

Right of Entry

FOR THE PURPOSE of examining points of emission, personnel of the state bureau and the local air pollution control commission should have the right to enter private or public property, subject to reasonable limitations so as not to unduly infringe on the historic sanctity of private property.

The conduct of investigating personnel should conform to established regulations (e.g. where special safety or fire precautions may be required) and cause a minimum of interference with operations.

Action by the State Bureau

WHEN registered information and investigation within a pollution zone confirm a cause-and-effect relationship between a certain emission and detrimental effects, the state bureau should recommend that the particular emission be decreased to an indicated level. This recommendation should be issued only after scientific investigation compels the conclusion that compliance will substantially lessen an unreasonable degree of air pollution, and will not constitute an unfair or unreasonable economic burden on the offender or the community as a whole. After validation by

the local air pollution control commission, the recommendation in the form of a directive should be sent directly from the state bureau to the offender.

Enforcement of directives through court procedure should be provided for in detail within the law. For example, if the offender advises the state bureau within sixty days of intention to comply, no further action may be taken so long as the offender manifests in good faith an intention to comply and acts with reasonable diligence; if the offender fails to advise the bureau within sixty days that he will comply or, having so advised, fails to proceed with reasonable diligence to effect compliance, the state bureau may be authorized to petition a designated court to effectuate the directive. Procedural provisions should cover expediting court review and decision to avoid unnecessarily prolonged litigation and delay; e.g. the statute might provide that an appeal shall be heard by the appellate court within 45 days.

The state bureau should be prohibited from issuing blanket regulations or restrictions and thus applying standards wholesale.

With the local air pollution control commission acting as intermediary between the state bureau and the offender, it is confidently expected that the responsible party controlling the source or sources of offensive emission, utilizing scientific information accumulated by the state bureau, will act in good faith to remedy the situation. Insofar as may be possible the state bureau should respond to requests from operators for technical assistance in solving their air pollution problems. Obviously the best way to solve the overall problem of air pollution is through whole-hearted cooperation, and a good law ought to provide a framework within which such cooperation can be fostered.

Cooperation in Technical Advancement

RECOGNIZING that advancement of technical knowledge is vital to solving the overall problem of air pollution, the state bureau should (a) conduct investigations of both the control and effects of air pollution and assist in solving the technical problems of air pollution control within the state, (b) consult and cooperate with other branches of the state government and with other groups in furthering the objective of the air pollution control law, (c) assemble and distribute information about air pollution and its control, (d) represent the state in dealing with interstate air pollution problems or in cooperating with international commissions.

Beyond these seven cardinal points, an air pollution control law needs additional provisions, such as penalties for failure to register emission sources (enforcement of state bureau directives should be left to the courts), use of state funds as well as authorization to receive funds from other sources both public and private, a statement of the relation of the statute to existing laws and ordinances, a statement of separability regarding the various provisions, etc.

Auxiliary Provisions

Zoning

IN LOCATING a new industrial plant, increasing attention is being given to selecting a site where air pollution will not offend an existing community. The operator has no assurance, however, that residential developments will not creep closer and closer to his plant, causing him to make additional expenditures for air pollution control and neutralizing one of the economic advantages which entered into his original decision about plant location.

For years zoning ordinances have prevented industry from moving into residential areas and adversely affecting property values. Only recently has attention been given to zoning regulations which would prohibit housing in designated industrial areas. Encouragement of such ordinances in an air pollution control law should help eliminate future problems.

Rapid Amortization of Control Facilities

ONLY RARELY does the investment in facilities for limiting and controlling air pollution become financially self-supporting, e.g. through by-product recovery. Accordingly, the cost is usually reflected in the higher price of finished products.

There is an alternative which can at least partly compensate for the added cost, and should be appropriate inasmuch as air

pollution control is in the public interest. This lies in providing for rapid amortization of facilities installed specifically for this purpose as direct encouragement to provide for air pollution control. Obviously any measure pertaining to federal taxes is outside the province of a state law, but accelerated amortization—for income tax purposes—of industrial waste treatment installations has already been proposed as an incentive to prevent water pollution.[7]

References

1. LANZA, A. J., M.D.: Health Aspects of Air Pollution. Presented at the 42nd Annual Conference of the Air Pollution and Smoke Prevention Association of America at Birmingham, Alabama on May 24, 1949.

2. STERN, A. C.: Problems in the Drafting and Administration of Air Pollution Control Legislation. *Modern Sanitation*, 2:34, December, 1950.

3. BARKLEY, J. F.: Fundamentals of Smoke Abatement. Bureau of Mines Information Circular 7588, December, 1950.

4. Senate Bill No. 9—46th Legislative Assembly—Regular Session; State of Oregon (1951).

5. BABBIT, H. E.: The Administration of Stream Pollution Prevention in Some States. Presented at the Sixth Industrial Waste Conference at Purdue University, February 21, 1951.

6. STERN, A. C. and GREENBURG, L.: Air Pollution—The Status Today. *Am. Jour. Pub. Health*, 41:27 (No. 1) January, 1951.

7. U.S. Senate Bill No. 1472 (Kefauver)—82nd Congress—First Session.

Report of the Local Sections Committee

AT THE request of WILLIAM T. MCCORMICK, Circulation Editor, *AIHA Quarterly*, a letter was written to the secretaries of all the Local Sections requesting that the president of each section appoint a Publicity Committee. One of the purposes of this committee was to promote the circulation of the *AIHA Quarterly*. Eleven Local Sections replied indicating that they had initiated this activity.

A circular letter also was written to the Local Sections at the request of the Editorial Committee Chairman, J. C. RADCLIFFE. It contained a request for the Local Sections to submit prospective papers for publication in the *Quarterly*.

The Local Sections Committee has been active in recent months with assistance to the AIHA members in the Dallas, Texas, area to establish a North Texas Section.

Letters have been written to the Local Sections suggesting methods of increasing associate membership.

At the request of HARRY E. SEIFERT, Director of the Bureau of Industrial Hygiene, Richmond, Virginia, a list of the National Members with addresses in Virginia was sent to him. He is interested in establishing a section in that area.

There seems to be an outstanding need for local sections in the Pacific Northwest, Canada, West Virginia, and Milwaukee. The Association has very few national members in the Southeast Atlantic states and the middle Gulf Coast states. The Local Sections Committee Chairman feels that activity toward promotion of eligible national membership in these areas should be given major emphasis in 1952-53.

All local sections have been urged to send news of their Association activities, to the *AIHA Quarterly* Editor. Deadline for all issues is the 15th of the month prior to the month of issue.

—J. W. HAMMOND, Chairman.

Public Health and Air Pollution

JOHN H. FOULGER, Ph.D., M.D.

THE INVENTION of the ultramicroscope almost 50 years ago opened up such a vast field for research and speculation on the physics and behavior of small particles that a German author coined the phrase, "the world of neglected dimensions."

Events during the last 20 years suggest that there is a world of neglected dimensions in our knowledge of the effect upon public health of materials in the atmosphere, which perforce we must breathe 24 hours a day every day of our lives. Why was it that in the Meuse River Valley in 1930 and in the Monongahela Valley at Donora in 1948 an atmosphere which had been tolerable and, indeed, which had been tolerated for many years suddenly became intolerable to many and lethal to some? Why was it that a rather thorough, though belated, investigation of chemical contaminants of these atmospheres should disclose no single component which alone could be responsible for the medical picture?

We are far too apt to pass off these two incidents as freaks, as due to meteorological quirks. I think we should not do so because, if we do, we may, on the one hand, neglect an extremely important field in setting up procedures for control of atmospheric pollution and, on the other hand, we may fall into the error of being too much influenced by the expected public outcry over Donora and pile up terrific costs for equipment and great wastes of power and dissipation of energy.

I think it important that we try to fit into our picture of general knowledge of the effects of atmospheric contaminants upon health both the Meuse River Valley incident and the Donora incident. The best way seems to be to review the information accumulated over the years on what chemicals do to human health.

WE LEARNED quite a lot about the effect of irritant chemicals over the period from April 22, 1915, when the Germans first attacked French troops with chlorine gas down to the Armistice on November 11, 1918. We certainly developed a mass of propaganda concerning what chemicals, and particularly so-called "poison gas," were believed to do to human health; but the actual medical record on the effects of gas warfare during the first World War is not known to the general public. Attempts to make it generally known during the second World War were prevented, as I know personally from my activities as a state gas control officer in Civilian Defense. The facts are these: In all armies engaged, allied and enemy, deaths as a proportion of total casualties from conventional war weapons were 25%. In all armies engaged, allied as well as enemy, deaths as a proportion of total casualties from gas warfare were 7.6%. During the period from late 1917 to November, 1918, when the American Expeditionary Force was operating in France, 31.5% of all casualties were due to gas—chlorine, phosgene, mustard and so on. Of the casualties due to gas, only 1.3% died. On the other hand, of the remaining 68.5% of total casualties, that is, of those due to conventional war hazards, 6.5% died.

After the war, medical officers in all allied countries studied the record for evidence of possible chronic injury from gas. As a result of surveys made by both the British Royal Army Medical Corps and the American Army Medical Corps, Vedder wrote in 1925 that "only a very minute percentage have suffered from any permanent disability directly caused by gas." He noted further that "There is not the slightest evidence that gassing has increased the liability to tuberculosis. So far as the evidence goes, men who have been gassed suffer less from tuberculosis than normal individuals under the same circumstances. Neurasthenic conditions are responsible for a considerable part of the disability alleged to result from gassing."

The public mind was so stirred by popular articles concerning the horrors of gas warfare that, when in 1920 claims were made by ex-servicemen in this country for

Presented at the Seventh Air Pollution Abatement Conference, Manufacturing Chemists' Association, Hotel Statler, New York City, February 25 and 26, 1952.

injury as a result of enemy action, there were 300,000 applicants for relief claiming injury from gas, whereas there was known to be only 70,500 cases of gassing in the American Expeditionary Forces.

The neurasthenic conditions found in those men who claimed injury by gas were not due to damage to the heart or to the respiratory tract. They were of mental and not physical origin. They were not due to any damage to the brain tissue by exposure to gas, but were rather the type of reaction which will quite frequently follow any form of physical or psychic shock.

Medical experience during the first World War was confirmed by study of the Brooklyn chlorine incident in 1944. Some of you may remember that on June 1, 1944, a truck was transporting some 27 cylinders of chlorine together with other chemicals from Bayonne, New Jersey, to a destination in Brooklyn, New York. Shortly after the truck crossed the Manhattan Bridge into Brooklyn, it was found that a cylinder containing 100 lbs. of chlorine was leaking. The driver of the truck turned to the curb on Flatbush Avenue extension just north of Myrtle Avenue and stopped. Unfortunately, he stopped at a point about 30 feet north of a subway entrance and only about 18 inches from gratings covering a ventilation shaft leading from the sidewalk to the subway platform. For about fifteen minutes the truck stood there with liquid chlorine to a total of about 100 lbs. dripping out through a hole in the bottom of the defective cylinder. Chlorine gas was drawn by suction down into the subway and affected passengers in the subway station and in trains stopping at the station. About four hundred persons received medical attention in this incident. There were no deaths. In this incident, as also in a later incident of accidental phosgene poisoning, the only residual effects were psychic rather than physical.

Exposure to irritant gases in gas warfare and in the civilian chlorine and phosgene incidents, of course, were acute and lasted only a relatively short time. The study of chronic exposure, day to day exposure over years, to concentrations of chemicals which are slightly irritant has shown that over five years at least, according to published data—and, in recent unpublished data, over 10 years—low concentrations of irritant gases such as chlorine, hydrochloric acid, sulfur dioxide and trioxide, hydrofluoric acid, phosgene, phosphorus oxychloride and trichloride, have not led to lung injury demonstrable by careful x-ray examination.

IN THE FIELD of action of dusts, we know that acute exposure to finely divided zinc oxide produces a form of ague, commonly called the "shakes." But we also know that chronic exposure to zinc oxide does not produce a chronic form of the "shakes." We know that acute exposure to lead fumes or lead oxide can produce acute lead poisoning and that chronic exposure to low concentrations of lead fumes, metallic lead or lead oxide will produce chronic poisoning; but the studies of Kehoe and his staff have shown that the concentrations necessary to produce chronic lead poisoning do not appear in the general atmosphere of industrial cities.

Acute exposure to finely divided beryllium compounds injures the lungs. So also can chronic exposure to low concentrations of these compounds. In one instance in an area of about three-quarters of a mile radius around a rather poorly conducted plant, beryllium in the atmosphere produced typical lung injuries. The one case which occurred at a greater distance from the plant was not due to beryllium in the general atmosphere but to the fact that a plant worker went home with his clothes heavily contaminated with dust of beryllium compounds and affected his family. The possibility that any form of beryllium poisoning of the lungs would occur in the general populace is extremely small.

The public has been greatly agitated by the suggestion that cancer might be caused by new chemicals inhaled from the atmosphere. We know that beta naphthylamine does produce cancer of the urinary bladder in a large proportion of animals exposed over a sufficiently long time to adequate concentrations and in men exposed to significant concentrations for many months or years in industry. It is highly improbable that concentrations necessary to produce injury will ever be reached in the atmosphere breathed by the average citizen.

In recent months, several papers have been written about cancer of the lung produced by inhalation of arsenic or bichromates. These are highly specific forms of injury which, should they occur at all in this country, are found in specific operations under industrial conditions of unnecessary exposure. It is inconceivable that the atmospheric concentrations associated with these forms of lung injury could appear in the general atmosphere of our cities.

WITH THIS REVIEW of our knowledge of what chemicals can do to human health, we still have no adequate explanation of the situation in the Meuse River Valley in 1930 or at Donora in 1948.

It is unfortunate that in our study of industrial hazards, and especially in quantitative studies aimed to establish what we termed "Maximum Allowable Concentrations" of atmospheric contaminants, we have, for quite practical reasons, confined attention to the study of a single contaminant at a time. There are almost no studies reported in the literature which deal with multiple contamination of the atmosphere and its effect upon those forced to breathe that atmosphere. In both the Meuse River Valley and in Donora there were many contaminants of the atmosphere. These ranged from known irritant gases which, however, were individually present in low concentrations, to compounds which are not considered irritant but, nevertheless, can have a physiological effect; for example, carbon monoxide and carbon dioxide. But these latter compounds also were not present in the concentrations which we usually find associated with definite physiological effects. There were present, also, in those atmospheres large numbers of solid particles of all kinds as well as liquid droplets.

Can it be that the presence in the atmosphere of two or three or more contaminants, each in a concentration too low to be effective according to present knowledge, might as a whole have significant physiological action? There exists some evidence that this situation does exist and the effects of two or more contaminants are not additive in the simple arithmetic sense. We have reason to believe that they may be additive in the exponential sense; that is, in the "compound interest law" sense. Thus, a low concentration, for example, of sulfur dioxide plus a low concentration of chlorine plus a very low concentration of another irritant, might have an intense action not to be expected from our knowledge of the individual activity of these particular compounds. Further, evidence is accumulating that if these compounds are adsorbed on particulate matter, especially on particles below 10 microns in diameter or upon small liquid droplets such as those existing in a fog, they can reach far down into the respiratory tract and can have a local effect far greater than that we would expect from the same quantities of chemicals if no adsorbing agent were present.

This possibility of unusual irritancy of an adsorbed irritant agent emphasizes the primary importance of removal of particulate matter in the atmosphere as a goal of atmospheric pollution control methods.

However, neither the theory of the exponential summation effect of a number of contaminants, each present in small quantity, nor the theory of enhancing the effect of irritant material by absorption on particulate matter explains the medical picture found in the Meuse River Valley incident or at Donora. The majority of the victims were, in the Meuse River Valley, the very young and the very old and, in the Donora Valley, the very old. Among these old people in both cases, injury and mortality were greatest among those suffering from diseases of the respiratory tract or of the circulatory system. These facts do not fit into our conventional idea of the specific action of chemicals on specific organs as demonstrable by the pathologist. We are entering now the realm of physiology; that is, of function. This has been almost entirely neglected not only in the study of industrial health but in the study of public health in general.

TWO SYSTEMS of the body must be functioning adequately if a child is to be born alive and these systems must continue to function if we are to remain alive. They are the respiratory system and the cardiovascular system.

At birth, most children have a function-

ing heart and circulation because during pregnancy they are attached to the circulatory system of the mother; but the lungs in a child just born are not always functioning and often one must perform acts, such as the old-time trick of holding the child upside down and spanking it, to start lung activity.

As we get older, one system or the other can begin to fail. If the respiratory system fails—as it can after acute action of chemicals—the victim can be kept alive by mechanical means, provided the heart is still beating. But, if the heart fails, death follows despite the fact that the respiratory center and the lungs may still be functioning.

The human body is most exposed to the atmosphere through the respiratory tract. At each breath it is possible to lay open to inhaled air 100 square meters of absorbing surface of the lungs backed up by an easily accessible blood stream. In contrast with this, the average man unclothed does not expose more than two square meters of his skin to the atmosphere and much less if he is clothed. Inhaled materials—gases, liquids or finely divided solids—which enter the blood stream of the lungs pass rapidly and directly into the brain. We know from 15 years of study that inhaled materials not normal to the body, if they reach the brain in sufficient concentration through the blood stream, can produce a rapid and detectable reaction of the circulatory system. As a result of this change in the supply of blood to all tissues of the body, there may be secondary responses in some tissues.

It is now a generally recognized theory, which we might call the theory of stress or, as Selye terms it, the "general adaptation syndrome," that the living organism, when exposed to a stress of any type—the stress of physical labor, the stress of disease, the stress of inhalation of foreign materials which may affect the circulation or may more seriously affect specific tissues, the stress of mental worry—combats that stress at once by some change within itself. But, in combatting this particular stress, it becomes less able to resist a second stress.

A sick man whose respiratory system is on the borderline of failure or one whose cardiovascular system is diseased and approaching failure is already under stress. He can succumb quite rapidly to another stress, particularly one which affects ability to breathe air into his lungs or the ability of his heart and circulation to supply adequate oxygen to the rest of his body. Under the same circumstances, a man whose heart is not impaired and whose lungs are functioning normally will not be affected.

This, we would suggest, was the situation in the Meuse River Valley in 1930 and in Donora in 1948. The temperature reversal at Donora, and probably in the Meuse River Valley, preventing proper air movement, led to accumulation of irritant and non-irritant materials and of particulate matter in the atmosphere. These materials acted upon the population of those two valleys as a stress over and above that which they ordinarily bore. Those who were healthy could survive. Those who were weak, particularly in their respiratory and cardiovascular systems, were either very sick or died. When they died, they did so primarily from cardiac failure or from pulmonary edema and secondary infections.

In planning our control of atmospheric pollution, we must always remember this situation. We must pay special attention to three things: In the geographical region in which we are interested, is there a possibility of temperature inversions such as occurred at Donora? In this region, is there the possibility of multiple exposure plus that of high concentration of particulate matter or moisture droplets which can act as adsorbing agents? In the geographical region in which we are interested, is there an accumulation of very young people or of old people; and, among these, are there many who suffer from respiratory or cardiovascular diseases?

If we attend to all these points while accepting the established fact that there is no hazard to the general population of our cities from atmospheric contamination by industrial chemicals, we shall, at the same time, be taking care of specific physiological situations in which hazards can be produced.

Some Factors for Air Pollution Control

H. G. DYKTOR
Commissioner, Division of Air Pollution Control
City of Cleveland

THE JOB of an air pollution control officer is a very interesting one and challenges all his capabilities. The nature of his job is such, however, that he cannot fully satisfy either the community or industry. The former looks for "complete" elimination of the pollution and the latter for the greatest results with the least expenditure, or none. Neither is usually attainable in practice.

The official in charge of an air pollution control program realizes that the presence and continued existence of industry is vital to an industrial community. His job is primarily to control air pollution, not necessarily to eliminate it, in the most practical and economical way possible.

It is well to consider four parts of a control program from the administrative standpoint.

The Problem of Air Pollution Control

NO ONE has as yet defined what air pollution is, but it exists in industrial areas. The people's demand for cleaner air is mostly justified and cannot be denied. Since one cannot depend on removal of pollution by the general atmosphere, other methods must be devised.

Facing up to this problem, discloses some fundamental factors which, briefly, are:

A. Sociological: Aspiration of the people for a better living environment and fear of the health angle. How far can this aspiration be granted and what are the health hazards, if any? We must have answers to these questions.

B. Economic: Tremendous costs of the controls which increase overhead but do not affect the quality of the product or reduce cost per unit. These can be ruinous to industry and, in any event, will be paid by the consumer.

C. Technical: While the solutions of many problems are known, particularly in the field of combustion, quite a few serious problems are not solvable at present. Much costly research is still needed.

Abstract of an address presented at the Seventh Air Pollution Abatement Conference, Manufacturing Chemists' Association, Hotel Statler, New York City, February 25 and 26, 1952.

The Aim of Air Pollution Control

CONTRARY to general belief, the people are not expecting elimination of all air pollution, and neither are the regulatory powers. The reason is that such a goal would be much too costly to attain. However, substantial reductions are expected and, eventually, a level must be reached where both community and industry can live in peace, side by side, if not in complete comfort.

This partial goal can be attained if common sense prevails and no specific health hazards are demonstrated.

What Can Officials Do About It?

SINCE THE activity is conducted by an official regulatory agency, it must be based on legislation. Brushing aside legislation written under emotional stress and presuming that serious consideration is given this matter, there are two paths open to officials:

A. Promulgate restrictive and punitive legislation and conduct the activity as a series of well publicized campaigns. This path will not result in satisfaction, either to the community or industry, as proved by experience. It will rather produce unnecessary antagonisms.

B. Promulgate legislation of the "performance" type which is reasonable, relatively simple and, most important, enforceable. This type of legislation grants industry the privilege of spending its money on its own property in a manner it wishes but demands results. It is predicated upon the desire of industry to cooperate and be a good neighbor.

What Can Industry Do About It?

INDUSTRY can do a great deal towards reducing air pollution, but much depends on its attitude.

If industry will not meet the needs of its neighbors then officials will step in with regulations with which industry will have to comply. This can be avoided by voluntary action by industry which knows its job best. Since legislation is a necessity in air pollution control, if for no other reason than for the few recalcitrants, industry must participate in the promulgation of regulatory legislation.

Industry and air pollution control officials must cooperate quite closely, not only for material improvement but for mutual education, and for public education, in order to attain the best compromise results.

Air pollution control is a highly complex problem, involving many scientific disciplines, legal and economic factors, and, above all, the human factor which is the least predictable of all. There is no panacea that can substitute for patience and hard work in a permanent program.

Activities of AIHA
American Association for the Advancement of Science

ALL MEMBERS of AIHA who were members of AAAS, as of the date of our affiliation with that organization, were blanketed in as AAAS Fellows by the endorsement of two Fellows, DR. MALCOLM SOULE (deceased) and myself. This was done on the basis that AIHA membership requirements were high enough that the rather vague AAAS requirements for Fellowship, involving no financial obligation, would be satisfied. So far there has been no objection to this arrangement.

We have 57 AAAS Fellows. *Thirty-six* of our members who are now members of AAAS may be required to furnish evidence of publications or office in a professional organization before being accepted to Fellowship. This will be followed up, and a means of elevating the majority—if not all of our members—to Fellowship, should be worked out soon. Our immediate goal is 100 or more Fellows, and that will entitle us to another seat on the AAAS Council. All AAAS members who have not yet done so should be encouraged to affiliate with Section P, Industrial Science.

At the request of AAAS, our Association sponsored an initial successful program at the annual meeting of AAAS in Philadelphia on December 28, 1951. The Section P program stirred rather wide favorable comment, and it is hoped that even greater interest will be shown in this year's program by both AIHA and AAAS members. Plans were made for publishing all the papers in Section P under one cover; however, the project has not yet reached fruition.

Plans are being made for another half-day program Christmas week at St. Louis. A Program Committee, largely selected from the St. Louis Section, has been appointed and instructed to develop a program that will fit into the theme of the meeting entitled "Contributions of Science and Mathematics to Engineering and Industry."

Tentative plans have been made to participate in the 1953 meeting at Boston, and the 1954 meeting at San Francisco. Unfortunately the meetings have been scheduled for Christmas week, as this is the time favored by the AAAS membership, consisting largely of educators and government employees. There seems little we can do about this at present.

The Society for Industrial Micro Biology has already affiliated with Section P. The American Society of Safety Engineers recently affiliated with AAAS and has been invited to affiliate with Section P. Efforts are being made by Section Secretary, N. V. HENDRICKS, markedly to broaden the AAAS interest in Section P and obtain affiliation of many groups with interests bordering or overlapping our own. If his enthusiasm and available time hold out, I believe nothing can prevent his success. AIHA has nothing to lose except a little extra effort by a few people, and we have an excellent opportunity to broaden understanding and appreciation of Industrial Hygiene.

—F. A. PATTY.

Wind Tunnel Techniques Used to Study Influence of Building Configuration on Stack Gas Dispersal

GORDON H. STROM, Ph.D.
Associate Professor of Aeronautical Engineering
New York University

WIND TUNNEL experimentation offers an approach often neglected in the solution of stack gas dispersal problems. Such use as has been made of this research tool has yielded answers difficult if not impossible to obtain by other means. Lack of familiarity with the possibilities and limitations of wind tunnel experiments on the part of designers of industrial installations is undoubtedly one reason for the present state of limited usage. Although used sporadically for many years in the study of gas dispersal problems, wind tunnel development in this field is in its early stages.

Stack gas dispersal problems most frequently investigated in the wind tunnel are those in which the presence of buildings and other nearby structures is an important factor. Such problems, sometimes termed as short stack problems, are difficult to solve except by experimental methods because of the complex nature of air flow patterns about buildings. Gas plumes which do not clear the turbulent wake downwind of a building will be partially or completely entrained and reach ground level in a short distance. In extreme cases the gases may travel upwind within the wake and envelop part of the building. In absence of restrictions on height, it is desirable to make stacks high enough to avoid detrimental effects of building turbulence. Use of empirical rules for stack height such as requiring a stack to be two and one half times the height of the building may lead to unnecessarily high and costly structures. Height of building is only one of several factors important to the problem. If the stack is high enough to be out of the influence of the building and surrounding structures, equations for plume characteristics may be successfully applied.

The relative ease with which a model can be modified is one of the advantages of scale model experimentation. Effect of changes in building shape on gas plume characteristics is one of the many factors which may be studied. Tests of a proposed building design will show whether it has undesirable characteristics and means for improvement may be found. Relocation of stacks and replacement of several stacks with a single stack are among the possible beneficial changes. Increase in stack gas ejection speed will result in considerable improvement particularly if the increase is sufficient to lift the plume out of the turbulent wake. Addition of a nozzle to a stack is one method of increasing ejection speeds. Studies of this type presuppose the control and measurement of stack gases. Omission of this feature is a severe restriction on the value of scale model experiments. Fig. 1 shows the result obtainable with a model employing smoke as the stack gas.

Among the factors difficult to represent in wind tunnel experiments is that of elevated temperature of stack gases. Complexity of model and equipment increases considerably. Experience with this type of experimentation is limited and further development is necessary for full realization of possible advantages. Fundamental questions with regard to scale factors arise. This situation does not preclude the study of heated stack gas problems when the influence of buildings is an important factor.

Inclusion of meteorological factors other than wind speed and direction has been practically non-existent in wind tunnel experimentation. Development in this direction holds the greatest promise for increased wind tunnel usage in atmospheric pollution studies. Omission of the important atmospheric turbulence characteristics is not serious in experiments on short stack problems of the type discussed earlier. Dispersal characteristics at greater distances from the stack are affected by meteorological factors and cannot be studied in wind tunnels at their present site of development.

Presented at the Seventh Air Pollution Abatement Conference, Manufacturing Chemists' Association, Hotel Statler, New York City, February 25 and 26, 1952.

OBSERVING and recording of stack gas experiments are usually done by making a pictorial record of plume shape. Most common is the use of visible smoke sketched or photographed against a rectangular grid on the far wall of the wind tunnel test section as shown in Fig. 1. Various chemical smokes such as ammonium chloride have been used. The corrosive nature of some of them is a disadvantage difficult to overcome in all except short test programs. The pipes which conduct smoke to the model as well as the stacks themselves become clogged. An oil fog type smoke produced by vaporization of heavy oil and condensation into fine droplets has been used with considerable success. While the equipment is more complex, the advantages justify its use for longer test programs. A mixture of air with small amounts of hydrogen sulphide has been used to obtain positive determination of areas contacted by the gas plume. Surfaces painted with a lead acetate solution become dark when exposed to this mixture. Plume cross sections are obtainable in this method by applying lead acetate to grids of string stretched across the airstream.

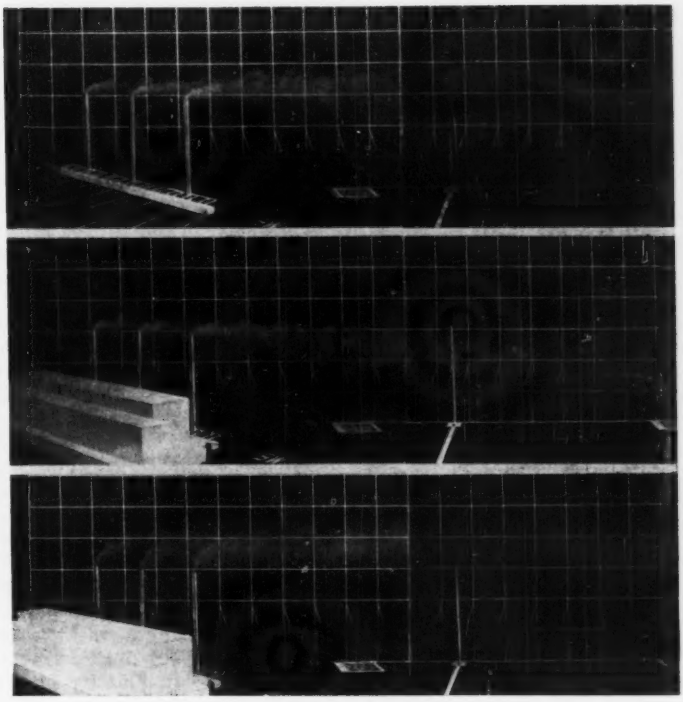


Fig. 1.
Smoke plumes showing variation in flow pattern. The upper and middle photographs at stack gas to wind speed ratio of one show the effect of a building. The lower photograph (ratio 3) shows the plume rise caused by increased ejection speed.

Measurement of gas concentrations in a plume would add much to the value of wind tunnel experiments but has rarely been attempted. Equipment problems and testing time are much greater for this type of experiment. Concentration of gases delivered to the stack as well as ejection speed must be controlled. The simple photographic method of recording is replaced with point by point measurements in the airstream. While the added cost may seem unjustified, quantitative information on plume concentrations particularly at ground level would be of immense value to the design of equipment for removal of contaminants from stack gases.

Studies of effect on plume characteristics of building shape are facilitated with observation of flow patterns about the model. Features of a building which cause bad flow conditions are difficult to detect without detailed knowledge of flow structure. Grids of tufts attached to strings across the airstream at or near the model are used for flow pattern studies. Tufts made of thread or light yarn two inches or more in length assume the local direction of flow and oscillate if in a turbulent region. This method is described and results presented in a

paper by von Hohenleiten and Wolf.[1] Smoke streamers flowing over the model are also used to study flow pattern. They give an excellent picture of flow conditions but are difficult to produce. The smoke tubes from which the streamers issue must be carefully designed to avoid local turbulence.

AN IMPORTANT phase of scale model experimentation is the application of scale or similarity factors which must be maintained to satisfy the physical requirements for true representation in miniature of full scale phenomena. These factors express the conditions for definite relationships among various kinds of fluid forces. The scale factor which applies to the stack gas ejection speed can be deduced from momentum characteristics. Stack gas momentum carries the plume upward and airstream momentum moves the plume horizontally. The forces between the plume and airstream result from changes in momentum. Similarity of force pattern which is necessary for similar paths of motion is obtained if the ratio of stack gas momentum flux to airstream momentum flux is the same for model and full scale. In terms of fluid characteristics the ratio of product of mass density and velocity squared of stack gas to that of airstream must be the same. This similarity requirement neglects viscous forces which have little effect on the plume trajectory as it leaves the stack. The initial features of a hot gas plume can be reproduced in the model without heating by proper selection of speeds to maintain the momentum relationship. For cases of equal stack gas and airstream densities the similarity requirement becomes the ratio of stack gas speed to windspeed.

Flow pattern caused by buildings and other surface features must have geometric similarity for correct representation of its influence on the gas plume. The turbulent wake behind an object is the result of the air viscosity. Although small, the viscous forces are sufficient to prevent the air from flowing smoothly around the edges into the downwind region. Reynolds Number, the scale factor for viscous fluids, contains the product of air speed and length of object. To obtain identical Reynolds Number values for model and full scale the wind speed must be increased as model scale is reduced. Scales of one to 100 or smaller are common in wind tunnel models of buildings. The necessary wind tunnel speed becomes absurdly high and would result in other effects which do not exist in the atmosphere. Fortunately Reynolds Number of the model need not be kept at the full scale value in wind tunnel tests of building shapes. The wake behind an object having curved contours changes with Reynolds Number because the point of flow separation shifts along the surface. On prismatic objects the flow separates at the sharp edges and is not appreciably influenced by the value of Reynolds Number except at very low speeds where the fluid inertia forces become small compared in the viscous forces. In stack gas dispersal experiments minimum wind speed for similarity of flow pattern can be found by observing the shape of the plume at various speeds for fixed ratio of stack gas to wind speed. Experiments on building models about one half foot high conducted at New York University showed no appreciable changes in flow pattern at wind speeds about five feet per second.

Correlative studies relating wind tunnel and full scale experiments are not as extensive as one would like. A few reports based on visual observations of smoke plumes show favorable results. Some years ago air currents in the Bay of Gibraltar were the subject of extensive investigation.[2] A one to 5,000 scale model of the Rock was tested in England in a four foot wind tunnel at a wind speed of 25 feet per second. Excellent correlation was found between flow patterns observed in the tunnel and at Gibraltar.

The flow about the cylindrical stack may or may not present scale problems. While the region affected by the stack is relatively small and will have little effect on the overall pattern, its proximity to the gas plume demands attention. Stack wake is broader at low Reynolds Number and tends to exaggerate the downwash of stack gases. At high ejection speeds momentum of stack gases carries the plume away from the wake influence. For stack gas speed to wind speed ratios less than one unnecessarily conservative downwash effects may occur. Sherlock and Stalker found no seri-

ous scale effects in their wind tunnel studies of stack characteristics.[3]

SIMILARITY requirements which apply to buoyancy characteristics of hot plumes present a difficult problem. For high gas ejection speeds and moderate buoyancy effects the initial plume shape is determined primarily by momentum characteristics and influence of building turbulence. Relative importance of momentum and buoyancy forces may be determined from equations for plume rise such as are given in a paper by Bosanquet, Carey and Halton.[4] Froude Number, the scale factor employed in hydrodynamic tests of ship models, applies to heated gas plumes. The common feature of these apparently different phenomena is the gravitational effect on fluid bodies of different densities. The ratio of speed squared to length of object is the similarity factor in terms of test variables. The severity of this scale factor is demonstrated with a typical case. A one to 100 scale model requires a wind speed of two feet per second to duplicate buoyancy characteristics of a 20 foot per second atmospheric wind. This is well below the minimum speed for similar flow patterns. One solution of this problem is the application of corrections based on plume rise equations to the plume height found by experiment. Omission of buoyancy characteristics is conservative and may be justified in many cases.

There are few wind tunnels designed specifically for study of stack gas dispersal and similar phenomena. Much of the work in the past has been done in wind tunnels designed for aircraft experiments. While such wind tunnels can often be adapted to gas dispersal problems, they lack some desirable features. The short test section limits the length of observable downwind region. Windows in the test section are usually too small for photographic requirements. Minimum operating speeds are frequently higher than those convenient for stack gas dispersal experiments. Complex force measuring equipment and high power requirements, two costly features of modern aircraft tunnels, are not needed.

As with other fields of experimentation the process of low speed wind tunnel development is slow and painful. Aircraft

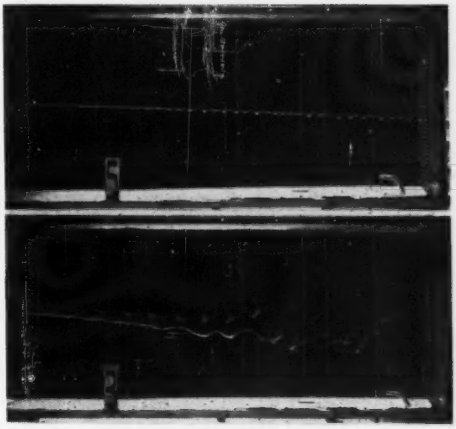


Fig. 2.
Smoke streamers showing effect of temperature gradient. Neutral unheated conditions exist in the upper photograph. An initial temperature gradient of -8°C. per foot elevation is maintained at the entering airstream to the left in the lower photograph.

wind tunnel experience has provided a fund of information in the past. Future development must be along independent lines and rest on a solid base of theory and correlation with full scale experiments. The time factor works against rapid development. Several years may pass before results of scale model experiments can be checked against actual full scale tests. Future development will include perfection of methods of application and techniques for measurement of gas concentrations. This appears to be largely adaptation of existing methods known to chemists. The greatest step forward and the most difficult will be the simulation of meteorological factors important to gas dispersion. Vertical temperature variation in the atmosphere, a characteristic intimately related with atmospheric turbulence, should be reproduced in the wind tunnel airstream. One program of development along this line is in process at New York University. Under the sponsorship of the Consolidated Edison Company of New York a wind tunnel was built for the study of gas dispersal problems. Development of equipment and techniques for airstream temperature and velocity gradient control is continuing un-

der the sponsorship of the Atomic Energy Commission. Preliminary experiments with airstream temperature control in the pilot wind tunnel show definite promise. Turbulent motion resulting from a temperature gradient hot at the bottom is shown in the lower photograph of Fig. 2. We at New York University are convinced that the techniques suggested offer relatively inexpensive means for studying pollution problems associated with stack gas emission and building configuration.

References

1. VON HOHENLEITEN, H. L., and WOLF, E. F.: Wind Tunnel Tests to Establish Stack Height for Riverside Generating Station, *ASME Transactions*, 1942, p. 671.

2. FIELD, J. H., and WARDEN, R.: A Survey of the Air Currents in the Bay of Gibraltar 1929-30, Air Ministry, Meteorological Office, Geophysical Memoirs No. 59.

3. SHERLOCK, R. H., and STALKER, E. A.: A Study of Flow Phenomena in the Wake of Smokestacks. University of Michigan, Engineering Research Bulletin No. 29, March, 1941.

4. BOSANQUET, C. H., CAREY, W. F., and HALTON, E. M.: Dust Deposition from Chimney Stacks. The Institution of Mechanical Engineers Proceedings, 1950, 162:3.

The Effect of Trichlorethylene on the Organism

THE effect of trichlorethylene on the animal organism is identical with the effect of a typical inhalation narcotic. The drug is volatile at ordinary room-temperature, it is as a rule administered by inhalation, it is absorbed without symptoms of irritation in the lungs, and in proportion to the magnitude of the dose it then gives rise to different degrees of narcosis. This narcotic effect has been thoroughly studied, and much experience has been gained, both experimentally and clinically. When exposure to trichlorethylene is stopped, it is eliminated to a large extent unchanged with the exhaled air, and the narcosis ceases relatively rapidly. There are as a rule no sequelae after a single narcosis or a moderate acute poisoning. In contradistinction to a number of other chlorinated hydrocarbons, such as carbon tetrachloride, trichlorethylene does not seem to cause any injuries to liver or kidneys, either in man or in animals .... AUTHOR'S SUMMARY: (1) Inhalation of trichlorethylene by human subjects and animals leads to excretion of trichloracetic acid with the urine and inconsiderable amounts with the feces. Also the administration of chloral entails the excretion of trichloracetic acid with the urine. Trichloracetic acid supplied in the form of a sodium salt is to a large extent converted in the organism, and at the most two-thirds is excreted unchanged with the urine, and only inconsiderable amounts with the feces. The excretion in human subjects begins 2-4 hours after a single exposure to trichlorethylene, and attains its maximum after 20-50 hours. After the inhalation of 0.5-1.0 g trichlorethylene the excretion continues for 1-2 weeks. Of absorbed trichlorethylene man excretes 6-16% in the form of trichloracetic acid with the urine. (2) The excretion of trichloracetic acid in urine shows a similar course after the inhalation of trichlorethylene, the supply of chloral and of trichloracetate. (3) The existence in the organism of a high content of trichloracetic acid does not change the resistance in mice to trichlorethylene in narcotic experiments. In rats, the subcutaneous injection of 1 g trichloracetic acid (as sodium trichloracetate) per kg body-weight does not give rise to any symptoms of poisoning. In this connection one finds concentrations in the urine of up to 7,900 mg trichloracetic acid per liter of urine. Exposure of rats to 80 mg trichlorethylene per liter of air for 30 mins., which produces as profound narcosis gives rise to at the most 1,200 mg trichloracetic acid per liter of urine. In man, who continuously excretes 300-400 mg trichloracetic acid per liter of urine after exposure to trichlorethylene, one nearly always finds pronounced symptoms of trichlorethylene effect, while in persons with the same concentration in the urine produced by supplying chloral, no such symptoms occur. In view of the facts adduced in this paper, trichloracetic acid is to be regarded as an only slightly toxic product of conversion of trichlorethylene and without decisive importance for the appearance of symptoms in cases of trichlorethylene effect.

—From "The Effect of Trichlorethylene on the Organism," by A. AHLMARK and S. FORSSMAN, in *Acta Physiologica Scandinavica*, 1951, Vol. 22, Fasc. 4.

Anticipating and Preparing Against Possible Industrial Hazards from Air Pollution*

GEORGE R. HILL

WHEN the invitation to address this conference was received, there came with it this request: "Would you speak on a hypothetical situation, assuming that you are reporting the results of an investigation, along with the recommendations arising from your findings, which you have made for a company having plans to build and operate a plant in the heart of a rich agricultural district where horticultural and dairying activities are carried out? The plant operations will give rise to gases and fumes which are to be dispersed by high stacks and/or collected and removed by proper engineering methods. However, the gases and fumes are known to be potentially harmful, both to foliage and livestock grazing on forage contaminated by such effluent. Your investigations in the area have covered topography, meteorology, plant and animal pathology. Your findings, both in plants and animals, reveal lesions that are similar to those known to be caused by the gases and fumes to be generated in the plant operations at a later date. Your method of recording the appearance of vegetation at intervals by aerial photographs in color and showing stack exhaust above an inversion would be of special interest to the audience."

This is a comprehensive order and at the same time an intriguing and challenging one. What industry would not like to know the hazards from operating a plant that of necessity must produce certain effluents which would constitute a nuisance and might be injurious to plant and animal life?

What factors should be considered in the location, construction and operation of such a plant in order to minimize these hazards to the greatest degree? Is it true that there may be discolorations on the leaves of plants, quite unrelated to air-borne effluents, which a farmer would be likely to attribute to the smoke from a manufacturing plant? How could such complaints be satisfactorily answered? Assuming that emanations from a certain plant occur in concentrations productive of injury, can the farmers be compensated therefor to the mutual saitsfaction of both parties, thus maintaining good will and avoiding expensive litigation or agitation for remedial legislation following such occasional occurrences? What are air pollution hazards, and how do they become such?

Since the physical laws relating to the dispersion of sulfur dioxide apply to all other gases as well as to liquids and solids which are fine enough to be relatively unaffected by gravity, it might be well to consider historically the problem of air pollution control as related to fumes and sulfur dioxide. Probably no other industry has been through such bitter litigation as the non-ferrous smelting industry. Smelters in large numbers have been enjoined and closed down by the courts over effluents—mostly solids.

THE SATISFACTORY treatment of smoke to remove the solids came about with the baghouse and a very few years later by the electrostatic precipitator called a Cottrell plant. Both the baghouse and the Cottrell are capable of 98 to 99% clearance in the removal of solids. Gases go through each undiminished.

Shortly after the turn of the century, metallurgists found that the metals from metallic sufide ores could be recovered if the sulfur they contained could first be roasted off. This discovery, coupled with the discovery that these metallic sulfides could be concentrated from less than 1% in ores, to high grade concentrates, by a stirring agitation of the finely-ground ore-water mixture with a small quantity of certain non-soluble substances, causing the mixture to foam and carry off as part of the foam, the valuable metals, has revolutionized the mining and smelting industry in the last generation. It added a very perplexing problem—what to do with the

* Presented at the Manufacturing Chemists Association, Inc., Air Pollution Abatement Conference, Hotel Statler, New York City, February 25-26, 1952.

sulfur dioxide produced by roasting these sulfide concentrates. When that gas reaches the ground in concentrations higher than 1 part per million, it becomes offensive to many people and, if it persists for an hour's time, can mark sensitive vegetation.

In 1916 the Murray and Midvale smelters were enjoined from operating, unless they could do so without the occurrence of concentrations of sulfur dioxide which would damage crops. They were given four years in which to make the necessary studies and effect remedial measures.

O'Gara, Fleming and Jones found that, although the sulfur dioxide was remarkably uniform in concentration and amount as it left the stack, that ground concentrations were anything but uniform. It was too dilute to be smelled or mark crops most of the time. Under certain weather conditions, however, ground concentrations were distressingly high. They found, from some tens of thousands of analyses, that the high peak of average concentration occurred, not at the stack, but a few stack lengths away, following which it decreased rather rapidly as distance from the stack increased. They measured these concentrations while the smelter was operating with a stack 200 feet high, then 300 feet high, and finally with one 450 feet high. They found a great decrease in ground concentration as height of stack increased. They thought to reduce the concentration in the stack still more by blowing three volumes of air into the stack for each volume of smoke. This further lowered ground concentrations, except following periods of dead calm. After one of these dead calms, lasting hours, they had the worst burn in Murray's history. The large diluter fan, which cooled the smoke as it diluted it, was immediately abandoned and a large coal burner was installed at the base of the stack to heat the smoke to greater buoyancy. This practice greatly decreased ground concentration, even during and following dead calms.

During such periods of very low wind velocity the smoke rises until it encounters air of equal density. Then it mushrooms out laterally in all directions until dispersed by wind of sufficient velocity. The height to which it will rise before thus mushrooming will depend upon its temperature. When that is the same as the surrounding air temperature it cannot rise beyond stack height unless forced out of the stack at great velocity.

Dr. O'Gara concluded that each degree Fahrenheit of rise in stack temperature was the equivalent of 2½ feet of added stack height.

Upwards of 95% of complaints of sulfur dioxide of high concentration from reasonably high stacks, occur during or immediately following prolonged calms. With short stacks, complaints may often occur in addition, whenever the smoke blows toward the complainant.

THE Selby Smelter found itself in difficulty with a new and rapidly-growing town about a mile farther up the Carquinez Straits. During the growing season the wind blows east up these Straits the major portion of the time. The smelter stack was only 146 feet high. Selby found it necessary to go to great expense for stack heating, and even then found it necessary drastically to curtail roasting operations, frequently hours daily, to avoid complaints from these new residential areas. This greatly increased the cost of treating ores.

Selby had long debated the construction of a tall stack. The smelter was located at water's edge in a half-mile-wide gorge. Hills several hundred feet high were on each side. The new housing extended to the very top of some of these hills. Might not a tall stack make matters worse by lifting the smoke to the same height as some of this housing before releasing it? How could one be reasonably certain?

Two standard wind vanes, one located on a hill at the height of the 146-foot stack, the other on a hill nearby 387 feet high, gave average wind directions differing by 45° from each other two-thirds of the time. Two toy balloons, one filled with an air-hydrogen mixture to air buoyancy and the other with hydrogen alone, were fastened together by a fuse string of such length that it would free the balloons at any desired height. The direction each balloon took was then charted by means of theodolites. After half a minute the direction of these balloons differed by 15° to 45°. The ground smoke frequently took still a different direction. This indicated that

smoke eliminated above 500 feet would be fanned out before reaching the ground again, as much as 15° to 45° in addition to the dilution due to stack height. This was confirmed by the observations of smoke ribbons laid down about 600 to 1,000 feet above the water in the Carquinez Straits and photographed at a few second intervals as they looped up and down and horizontally.

The new Selby stack, 605 feet high, went into operation October 7, 1937. It solved the sulfur dioxide problem completely. The ensuing 15 months there was recorded on a Thomas SO_2 autometer, located on Dillon Point, 2.6 miles easterly up the Carquinez Straits, an amount of sulfur dioxide exceeding 0.5 ppm for a half-hour period, only once, and then it was only 0.52 ppm. For the preceding 42 months, from the 146-foot stack, in curtailed operations during critical times, an amount of SO_2 in excess of 0.5 ppm for a half-hour period, had been recorded 842 times. The average concentration during these 842 occurrences above 0.5 ppm was 0.72 ppm. The average concentration from the short stack during the preceding 42 months was 0.057 ppm. The average concentration from the tall stack was 0.025 ppm. During 1008 half-hour periods while the Selby plant was not operating, it was 0.013 ppm. This tremendous success in air pollution control was achieved by raising the stack height from 146 to 605 feet.

About this time Bosanquet and Pearson published in the Faraday Society reports, a theoretical equation based on voluminous studies of smoke from chimneys of different heights in England, which in substance said this: The concentration of an effluent reaching the ground from a chimney varies inversely as the square of chimney height; the peak of concentration occurs about 10 chimney lengths from the base of the chimney; reduction in concentration extends some 50 chimney lengths, following which the concentration varies inversely as the square of the distance from the source. This would mean that the concentration from the 146-foot Selby stack should be about 16 times as great as the concentration from the 605-foot stack.

The performance of the tall Selby stack has been far better than this 16 to 1 ratio in preventing high peaks of concentration —this probably as a result of the spreading effect due to the differences in direction of the wind at different elevations. No complaints have come since the tall stack was cut in. Stack heating has been unnecessary. No curtailment during critical weather has resulted in greater efficiency of operation.

Often the smoke from the tall Selby stack can be seen blowing in one direction and the ground smoke blowing in another. It was this abundantly-demonstrated fact, coupled with the known effectiveness of tall stacks, that finally convinced the American Smelting and Refining Company officials that a high stack would probably solve the difficulties in this difficult terrain.

TURBULENCE, an almost constant characteristic of wind blowing from high to quite a low velocity, enables the wind adequately to disperse gases, once they are carried high enough into the air as not to be blown immediately to the ground again. The *significance* of this property of wind is often very little appreciated by construction engineers who plan manufacturing plants. This characteristic, turbulence, is that restless tendency of wind to shift in direction horizontally and vertically from some 45° to more than 90°, 50 to 150 times an hour.

At about 25 miles an hour the wind vane makes some 150 swings back and forth per hour through an amplitude of some 45°. At five to eight miles per hour the number of these swings is reduced to some 50 per hour, but the amplitude of swing is much greater, occasionally reaching 180°. When the velocity drops below three miles an hour, instead of the 50 or more swings, these swings virtually cease and smoke piles up. At such times, facilities for carrying the liberated smoke high and hot to the inexhaustible reservoir of the upper air is a good means of preventing annoying ground concentrations.

Most calms giving rise to complaints occur when the wind velocity is so low as to be without the spreading effects of these rhythmic swings. Only a fraction of such calms, however, when high stacks are employed to effect dispersion, are accompanied by annoying ground concentrations. Since

the tall Murray stack demonstrated the principle, many other smelters have adopted the same means of overcoming air pollution hazards.

That the upper air has tremendous power to swallow up air pollution is further seen in the fact that St. Louis, Chicago, and Pittsburgh throw into the air enough sulfur daily, to give a sulfur dioxide concentration of one part per million throughout an area of 30 miles radius to a depth of a quarter of a mile. Yet in studies made in these cities during the winter months, when concentrations are the highest, one part per million was rarely encountered. The average for St. Louis was 0.147 ppm, and for Pittsburgh 0.064 ppm. Figures were not available for the Chicago average.

Wind direction and velocity may now be recorded directly on the same recorder roll on which the sulfur dioxide record is made. Such recordings furnish an excellent means of quickly correlating wind direction and velocity with concentrations of sulfur dioxide at ground level.

A knowledge of the frequency and duration of calms is indispensible to a proper appraisal of hazards from plant operation. A method of forecasting the occurrence of calms of over three hours duration would be invaluable. Then an operator might so stagger his operations as largely to avoid creating a nuisance. Prolonged calms are not of very great frequency in most places.

A study of the frequency and duration of calms for the Central New Jersey area, revealed that while prolonged calms were recorded, they were of rare occurrence. For example, one of 11 hours and two of seven hours each, occurred in 1928. At Salt Lake City in 1928 they were about 10 times as frequent. Periods of similarly low wind velocity were recorded at Trenton and at Sandy Hook in 1928, beginning and ending at almost the same hour as New York. These three prolonged calms in 1928 indicated that such calms sometimes cover considerable territory.

AN INTENSIVE study of air pollution problems at a score of smelters for a period of more than 25 years has revealed the fact that no two smelters have the same problems. Rarely are the problems of a given smelter alike any two years. Yet a rather uniform elimination of sulfur dioxide from similar roasting operations occurs at all of them. This would indicate that air pollution problems are peculiarly local problems. Their extremely local nature may be explained on the basis of differences in topography, differences in local meteorology, differences in the frequency, duration, structure, and nature of calms and temperature inversions, differences in the variability of winds, and differences in industrial location and set-up. How foolish it would be, how lacking in knowledge of the ideosyncrasies of temperature inversions, all different because of differences in these factors, to assume that they could be controlled equitably by a statewide or nationwide law!

The rainfall on Diamond Head on the Island of Oahu is a scant 9 inches a year. On the Pali above Honolulu, about 10 miles from Diamond Head, it is more than 300 inches a year. A storm sewer law applicable to the entire island would be ludicrous. The equally irregular distribution of masses of calm air determine the extent, frequency, and intensity of air pollution for any given community. How similarly inequitable would be a statewide law to regulate these widely differing problems!

It is not with average concentrations, but peak concentrations occurring once in a "blue moon," then at times of low wind velocity and frequent temperature inversions, that complaints come.

Let us consider temperature inversions. These, for example, are entirely unlike at Los Angeles, at Salt Lake, and in the Columbia River Valley below Trail, British Columbia. In this latter region a zone of little turbulence catches the sulfur dioxide from the Trail smelter and channels it in a thin layer a thousand feet above the river in this half-mile deep gorge, slowly down the river during night and early morning hours. From about 11:00 A.M. till nightfall it similarly channels it up the river. When the morning sun warms up the air on the west side of this canyon, it causes the warmed air to rise and the colder air on the east side of the canyon to fall, resulting in a simultaneous fumigation from Trail to Evans, 40 miles farther down the River.

At Los Angeles a temperature inversion comes in apparently from a non-turbulent

mass of warm air over the ocean and reaches the mountains beyond Los Angeles and Pasadena in the late morning hours, covering the Los Angeles basin like a lid. The inversion layer begins 300 to 1,000 feet above the ground and extends upwards some 1,000 to 2500 feet.

A third type of temperature inversion occurs in the eastern part of the Salt Lake Valley. This is strictly of local origin. It extends from the ground upward to a height of a thousand feet or more. It is of very frequent occurrence. It usually begins near sundown by the more rapid radiation of heat from the surface of the ground than from the air above it, whenever the sky is clear and there is too little wind to mix the air.

For the past 10 years the Department of Agricultural Research of the American Smelting and Refining Company has been measuring this by means of recording thermometers on the KDYL radio tower, one at 385 feet above the ground, one at 15 feet, and two between. Wind velocity is measured at the laboratory a quarter of a mile southeast.

During the winters of 1946-47-48 many Kodachrome panoramic pictures were taken about sunrise on 132 different days from a bench in the central part of the 15-mile-wide valley, where there is usually enough wind to prevent the formation of inversion layers. These show this imprisoned smoke blanket and the mountains above it standing out sharp and clear.

These pictures show a typical smoke blanket extending along the base of the Wasatch Mountains to the northeast, east, and southeast. The Murray and Midvale 450-foot stacks, frequently reaching above the smoke blanket can be seen. To the southwest, west, and northwest, the Oquirrh Mountains can be seen with clear air extending to the very base.

An interesting feature of these smoke blankets is the fact that they are stratified. The lowest is a stratum of black smoke at housetop level from 50,000 homes burning soft coal. Before Diesels replaced coal-burning locomotives, this smoke also was in this low black stratum. Next is seen a stratum of dark gray smoke about 200 to 500 feet above the ground, from short industrial smoke stacks. Occasionally a third stratum, a thin horizontal ribbon of whitish smoke at about 1,000 feet above the ground, is seen. This can be seen rising diagonally several hundred feet from the Murray and Midvale 450-foot smoke stacks, and then flattening out when a stratum of equal air density has been reached.

Other pictures show beautiful Salt Lake City, taken a quarter mile south of the mouth of Parley's Canyon on Highway 40, completely hidden in a cloud of dense black smoke. To the southwest, that whitish vertically-rising column of smoke is from the Murray stack. It rises for several hundred feet *through* the black smoke blanket which has completely obscured the Murray smoke stack, and then vanishes, presumably because it has reached the top of the inversion layer. A picture was taken about 20 minutes later, six miles west and three miles south of the preceding one. It shows the same Murray stream rising from the smelter stack and rising some 800 feet to disappear as it did in the preceding picture. This entire smoke cloud vanished about one and a half hours after these pictures were taken, when the sun had overcome the temperature inversion, releasing the imprisoned smoke. This was rather quickly sucked up into the vast reservoir of the upper air as by a magnetic sponge.

The temperature at the 385-foot tower station frequently reaches 15-25° F above ground temperature from 2:00 A.M. to 6:00 A.M. It was 3° above at 8:30 A.M. when this last picture was taken.

We have much less exact information about temperature inversions and their idiosyncrasies than about any other weather factor. We cannot hope to achieve economic air pollution control without exact knowledge concerning them. Recording thermometers are not prohibitively costly. Tall radio towers dot the landscape. The temperatures can be automatically recorded every minute on the revolving chart of a recorder. This roll of paper lasts 40 days. A brief half-hour visit once in 10 days by even a high school physics student to service the recorders and to see that the rolls of recorder paper are renewed when necessary, would give a record by which any community could analyze this type of acute air pollution problems. Then hopefully a method could be devised for taking ad-

vantage of this information to the advantage of both industry and community.

To measure the characteristics of temperature inversions beginning 500 or more feet above the ground, it should be possible to attach radiosondes to the cord by which a captive balloon is attached, every 250 feet as the balloon is reeled out. This might give a continuous automatic record, to the height of half a mile, of the beginning, height, gradient, duration, and other characteristics of an inversion. The captive balloon might also be automatically reeled in when the wind reaches any certain velocity, thus preventing loss or damage to the equipment.

A STRONG department of public relations has been found by certain companies to be of tremendous importance in dealing with farmers and the public in general, particularly following a weather accident resulting in an annoying fumigation. Farmers in general are the finest of open-minded people. They do not want their crops to be damaged nor has industry the right to damage them. Such damages, when they do occur can be estimated by a skilled appraiser and paid for to the mutual satisfaction of the company and the farmers by a good public relations man who also knows crops, their diseases and pests, and the characteristics of smoke damage to them. One company, with many plants in this and other countries, has not had a single agricultural lawsuit in more than 25 years by following this policy. To ignore such fumigations or treat them as acts of God, for which the industry is not responsible, is one of the surest ways of bringing on litigation, to be followed by demands for drastic legislation. In the bitter emotions aroused by such a fight, balance of convenience between industry and the community it serves may be entirely lost sight of.

Very often markings due to a myriad of other causes are discovered by a farmer, who believes that they are caused by smoke. This constitutes a real hazard to industry. If the farmer cannot be shown and convinced of the real cause he will fight as hard as though smoke were the cause.

An alert crop inspector will soon recognize that crops vary widely in their susceptibility to sulfur dioxide or other gaseous injury. Before drawing conclusions he will seek the confirming evidence from equally susceptible plants. Not infrequently a crop inspector, and often a farmer, has jumped to the conclusion that a bad case of "white-spot" discoloration on alfalfa was caused by sulfur dioxide. An exposure to sulfur dioxide of an intensity conspicuously to discolor alfalfa, will likewise mark other susceptible crops and weeds. A competent inspector will make frequent inspections in areas far removed to make doubly sure on this point. Often he will be able to set the farmer's mind at ease by taking him to see such crops.

The leaves of plants are temporary structures, specialized quickly to absorb carbon dioxide from the atmosphere and in the presence of sunlight to manufacture carbohydrates therefrom. To this end leaves are exceedingly porous. The waterproofed epidermis is underlaid by a very loose meshwork of connecting cells and large intercellular spaces. These spaces are much more abundant between the veins of leaves than along the veins, because the veins must also serve the leaf as conductors and for strength. The interior of leaves has from 15 to 50 times the area of the surface of the leaf, and this surface is always moist to facilitate the absorption of gases.

Solids and liquids are excluded from the interior of leaves by the stomata. All gases are equally free to enter. Sulfur dioxide, 30 times as soluble in water as carbon dioxide, is absorbed with avidity. It is absorbed most rapidly in the most porous parts of these fully-grown highly-functional leaves. A collapse of those cells most exposed takes place whenever too much has been absorbed. These cells die and bleach. This leaves a distinctive pattern by which sulfur dioxide markings can usually be differentiated from those produced by other causes.

The less porous parts of plants—the buds, flowers, stems, and fruits—are rarely marked by sulfur dioxide at all, and not unless the fumigation has been sufficiently severe entirely to defoliate the plant.

The leaves of some species of plants absorb sulfur dioxide from a given fumigation several times more rapidly than

the leaves of other species. Such plants are called "SO_2 sensitive" as distinguished from the slow absorbers which are called "SO_2 resistant."

Alfalfa, barley, rye, wheat, oats, cotton, peas, lettuce, squash, cosmos, ragweeds, and sunflowers are all SO_2 sensitive. Apples, pears, grapes, sugar beets, potatoes, and tomatoes are intermediate. Corn, peaches, apricots, celery, cucumbers and cantaloupes are SO_2 resistant crops. The order is not the same for other gases. Corn and apricots are among the most sensitive to fluorine, but very resistant to sulfur dioxide. Gladiolus is very sensitive to fluorine, but is intermediate in SO_2 sensitivity.

Because of their ready absorption, water soluble gases quickly accumulate in the leaves of plants until a leaf may contain many times the original content of that substance. When the exposure is over the gases rather quickly disappear, some going back into the air again, but mostly they are fixed in the leaf by calcium or other bases. In the case of sulfur dioxide, it is quickly oxidized to the 34 times less toxic sulfate and is used by the plant in its nutrition.

Attention was called in this paper to a great variety of leaf discolorations due to virus diseases, fungous diseases, mineral deficiency symptoms, and weather effects, all unrelated to industrial effluents, which are nevertheless mistaken by farmers for smoke markings. Such discolorations on alfalfa, cotton, corn, peach, cherry, plus, and apricot leaves were copiously illustrated with Kodachrome slides. Attention was called to a court injunction against, and the dismantling of, a brick kiln in Canada, because of alleged injury to a peach orchard by smoke from the brick kiln. The following year the discolorations on the peach leaves worsened and were diagnosed as being caused by the Western X-virus disease.

If you were to construct a new plant from which complaints conceivably could come in the future, Kodachrome aerial pictures might show what fields and orchards looked like before you began operating. Such pictures save endless disputes at the close of the season or at a later time.

SUMMARY: The attempt has been made to show:

1. The causes of acute air pollution.
2. The nature of meteorological conditions favoring heavy smoke concentration and its dissipation.
3. The laws governing gaseous dispersion.
4. The tall stack as one means of taking advantage of those laws.
5. The urgent need for more knowledge of the nature and characteristics of temperature inversions.
6. A means by which a community may study the effect of local topography on temperature inversions and resulting air pollution problems.
7. The "sea-captain" method of operations, by which some companies are able to avoid causing nuisancesome concentrations of effluents at critical times.
8. The opportunity, through a competent personal relations department of handling real problems of damage and of dissipating unrelated claims.
9. The similar and different effects of some gaseous air pollutants on the leaves of plants.
10. The value and use of a pictorial record in dealing with farmers or the public.

Area Air Pollution Problems and the Individual Plant

HAMNETT P. MUNGER,
In Charge, Air Pollution Research,
Batelle Memorial Institute,
Columbus, Ohio

THE more complex air pollution problems are usually associated with population centers. The larger the city and the larger the surrounding industrial area, the more difficult is the analysis of the problem.

In all of these areas, it is necessary to locate the principal sources of contaminants, and to study the most economical method for reducing their concentrations in the effluent gases from each individual plant.

How may air pollution be defined? In the Manufacturing Chemists' Association Manual, it is defined as "the presence in the air of substances put there by the acts of man, in concentrations sufficient to interfere with the comfort, safety or health of man, or with the full use and enjoyment of his property." This is a commonsense definition. It does not specify definite limits for the contaminant concentration of effluent gases, regardless of topography, meteorology, and other factors. It takes into consideration the ability of the atmosphere to disperse contaminants, and man's use of tall stacks and other devices for minimizing the nuisance of industrial contaminants. It recognizes that there will be a difference between the air in a residential area and an industrial area, so long as it does not interfere with "comfort—health—and the enjoyment of property."

Nature of the Air-Pollution Problem

IN ALL of our communities, we must recognize that there are many potential sources of air pollution other than industry. Among these are the railroads, public buildings, schools, incinerators, small commercial boiler plants, and other locations where combustion processes are carried on. When only one plant is located in a community, it is usually not difficult to locate the source of the contaminants. The nature of the pollution and simple observation should be sufficient.

In a large industrial area, the problem becomes more complex, and other means must be employed in air-pollution studies. Topography may become an important factor. This was evident at Trail, British Columbia, Donora, Pennsylvania, and Los Angeles. Full discussions of these cases are found elsewhere.[1,2,3]

Meteorological conditions in the form of inversions, fogs, and extended periods of low wind velocity may result in difficulty due to the accumulation of contaminants in a local area. These factors are especially important when considering the location of a new plant. In such cases, the plant design should consider not only the small community which may be nearby, but also the inevitable growth of the community right up to the very gates of the plant.

Kinds of Air Contaminants

IN ANY study of air pollution in an industrial area, the problem of contaminant concentration is usually divided into three parts, depending on the particle size of the contaminants,[4] namely, dirt fall, aerosols, and noxious gases. Methods for sampling and determining concentrations of these three classes of contaminants have been described elsewhere.[5,6] Many of these methods have the objection that they determine the amount of contaminant present during only a very small portion of the 24-hour day. It is well known that these contaminant concentrations vary widely with the time of day and with different meteorological conditions.

Dirt-Fall Measurements

CLEARLY, it is important to obtain an integrated picture or a continuous record of the contaminant concentration in studying air pollution for a metropolitan area. Conventional dirt-fall measurements[8] are one of the methods available for this type of study. The usual method for these meas-

Presented at the Manufacturing Chemists Association, Inc., Air Pollution Abatement Conference, Hotel Statler, New York City, February 25-26, 1952.

urements is to expose a collection jar for 30 days and determine the amount and nature of the dirt which falls into it. There are many details to be considered if the results are to be reliable. Among them are:

1. That the location of the jar is truly representative of the area it is to represent;
2. That it will not be affected by local conditions;
3. That the container has the proper size, shape, and contour;
4. Method of interpreting and presenting the results, and
5. The effect of local meteorological conditions, and many others. This subject is too large to be considered here and will probably be the subject of future papers.

The simple dirt-fall jar indicates how much dirt has fallen at a location but gives no clue of the origin of the dirt. To fill this need, a directional dirt-fall collector has been developed by Battelle, as shown in Fig. 1. The dirt which falls while the wind is blowing from various directions falls in one of the eight peripheral jars. When the wind velocity is below three miles per hour, the dirt falls in the calm jar, in the center. An auxiliary wind vane controls the positioning of the cover so that it is always over one or the other of the sampling tubes. When the wind velocity is above three miles per hour, the outer tube is open; when it is below this velocity, the center tube is open. A more complete description of this instrument is given elsewhere.[9,10] Pilot models are giving satisfactory performance in the field.

It is also necessary to know the number of hours the wind blows from various directions in order to calculate the rate of dirt fall. A recording anemometer can be used to furnish this record. A new directional wind-hour meter is being produced to furnish this information from direct-reading dials. This instrument will simplify the calculation of results obtained from the directional dirt-fall collector.

With this equipment, it should be possible to correlate the direction from which the wind is blowing with the highest rate of dirt fall. In addition, analyses of the dirt samples in various jars might give clues as to their sources. If a large metropolitan area were divided by a river, several of these directional dirt-fall collectors, located along the river, might give information indicating from which side of the river the dirt falling in the area was coming.

In any highly industrialized area, this collector would be useful in correlating the relative dirt fall with wind direction.

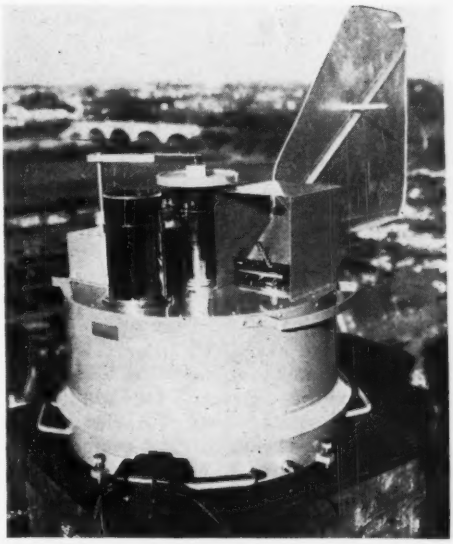


Fig. 1-A.
Directional dirt-fall collector, showing operating position when wind is blowing in excess of three miles per hour.

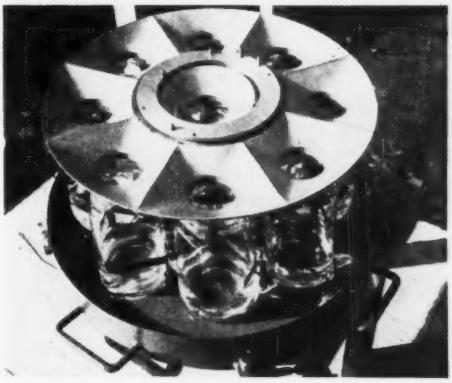


Fig. 1-B.
Directional dirt-fall collector with outer cover removed.

Aerosol Determinations

EARLY determinations of aerosol concentrations were made in England by Owens,[8] and in this country by Ward Davidson,[11] of Consolidated Edison Electric Company. During the past several years, a number of continuous aerosol filters have been designed.[12] All of these depend upon drawing a predetermined amount of air through a definite area of filter paper. The discoloration of the paper or its light transmission is used as a measure of the aerosol concentration. In some cases where the time period is extended, the spot may be analyzed chemically.

This type of equipment has been used extensively in England for studies in smoky, industrial areas. Its use in this country has been limited by the number of man-hours required to collect and interpret the data. With the increasing interest in studying air pollution in industrial areas, it is possible that the use of such equipment will increase. The data from such studies will be much more valuable if they are correlated with wind direction.

An aerosol meter which would sample the air and measure and record its aerosol concentration is in the design stages. This equipment could be made to differentiate between black, tarry aerosols and light-colored aerosols, similar to fly ash. Automatic recording of wind direction would be included. The development of this equipment could be carried forward rapidly if there were sufficient demand for it.

Aerosols may also be collected continuously in impingers and Venturi scrubbers. These methods may be designed to include use of the directional-sampling principle. This subject will be discussed under "Gases."

These methods have not been widely used in air pollution studies except in Los Angeles.[3,13] A high volume air sampler has been developed for filtering aerosols from the air.[23] Samples may be collected over periods of 24-72 hours. It is currently being used in the Detroit area in studying air pollution along the Detroit River.[24]

Determination of Gases

THE GAS which has received the most attention in air-pollution studies is sulfur dioxide. The conventional instrument for continuously recording its concentration in the atmosphere is the Thomas Autometer.[14] It is understood that the Autometer may now be engineered to include a device for recording the wind direction, as well as sulfur dioxide concentration on the chart. An instrument[15] for measuring the concentration of sulfur-bearing gases, depending on their oxidation by bromine, is also commercially available.

In certain areas, effluent gases containing fluorides may be important. Methods for making individual determinations for fluorides are available, but there is no instrument for continuously measuring their concentrations in air at the present time. One of the reasons is that the concentrations which appear to be important are "parts per billion" instead of "parts per million." Instrumentation for continuously measuring fluoride concentration is under investigation by the ASTM Committee D-22 on Air Pollution.

Many other gases may be important in specific locations. Unsaturated hydrocarbons have been shown to be important in Los Angeles.[3,17,18] Gases and odors from the chemical and food-processing industries are sometimes found objectionable. These problems are not sufficiently widespread to require that continuously recording instruments be developed.

In sampling gases or aerosols continuously, the directional principle could be employed if desired. To do this, nine sampling bottles are connected through solenoid valves to a vacuum pump. The solenoid valves are controlled by eight segments on a wind vane—one for each of the eight points of the compass. The ninth valve for calm periods or wind velocities below three miles per hour would be operated by a wind-velocity-sensitive vane. In this case, also, the wind-direction hour-meter would be required to correlate concentration with time elapsed. Similar results could also be obtained for gases using a modified Thomas Autometer.

Short-Time Sampling and Analyses

STANDARD methods are available for sampling aerosols and gases and for analyzing these samples for various chemical constituents.[5,6,7] It is important that the particle size[14] and chemical nature[19] of the

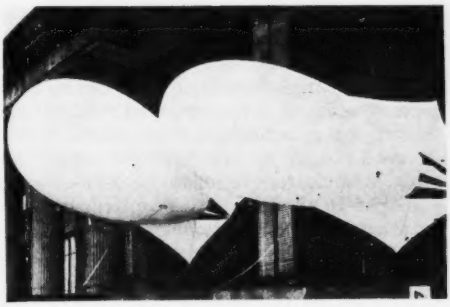


Fig. 2.
Kite-balloons used to support sampling devices and meteorological equipment at low altitudes.

contaminant be known so that appropriate methods and techniques may be employed. For these data to have the maximum value, they should be correlated with meteorological parameters and topography.

One of the newer methods of sampling involves the use of kite-balloons[20] as shown in Fig. 2. By this means, polyethylene tubing may be raised to various altitudes to collect gas samples. These gas samples are drawn to ground level for analysis. Similarly, an electrostatic precipitator may be raised to various altitudes, as shown in Fig. 3, to collect samples of particulate matter. Meteorological data may also be collected by this technique. Wind velocity and direction are determined in the field by raising a hot-wire anemometer (Fig. 4), using a kite-balloon as a sky hook. In this way, micrometeorological data in the "earth-bound" contaminant air layer are obtained without the aid of permanent structures.

The kite-balloon technique has also been used to study the air-flow pattern over the top of industrial buildings under various meteorological conditions.[9] The smoke from a smoke grenade, supported by a kite-balloon and fired at 235 feet, is seen in Fig. 5. The path of the smoke grenade fired at 380 feet is shown in Fig. 6. Note that the added height permits the smoke to travel horizontally, instead of being carried downward in the lee of the building.

All of these techniques permit a study of the potential air-pollution problems of a new plant site before the shovel starts excavating for the building foundations.

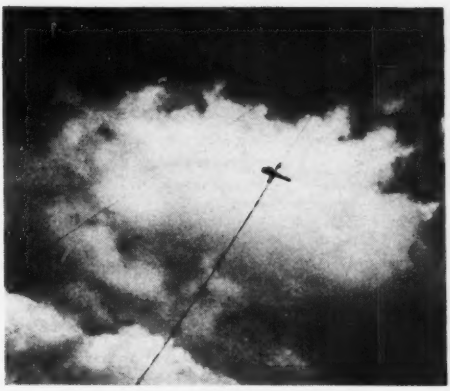


Fig. 3.
Electrostatic precipitator for collecting particulate matter raised by kite-ballon.

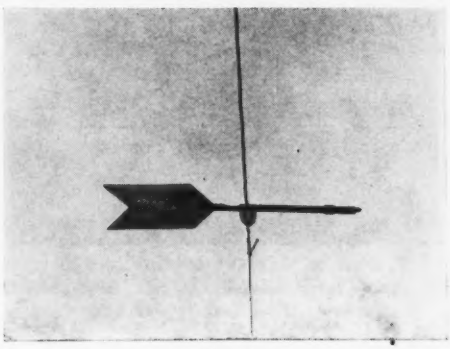


Fig. 4.
Hot-wire anemometer for measuring wind velocity and wind direction at various altitudes.

More detailed information concerning the use of these techniques is available in the literature.[9,20]

Sources of Air Pollution

MUCH has been said about studying air pollution, and considerable work has been done on how it may be reduced. In industrialized areas, this can be done only by carrying on a systematic study. Such a program will consist of three parts:

1. A determination of the nature and source of the contaminant or contaminants responsible for the air pollution.

2. A determination of the properties and concentrations of the contaminants in different parts of the area and at the sources.

Fig. 5.
Smoke bomb released at 235 feet above ground. Wind velocity was 10 mph.

Fig. 6.
Smoke bomb released at 380 feet above ground. Wind velocity was 9 mph.

3. An investigation of the methods which may be used at the source to secure the most economical process for reducing the contaminant concentration in the effluent gases and in the community.

There will be a great variation in the ease with which the source and nature of contaminants can be determined. If the number of plants is small, or the contaminant easily identified, this part of the problem will be simple. In highly industrialized areas, the problem becomes much more difficult. Of course, it will be necessary to use directional collectors and continuous recorders to measure the variation of contaminant concentration with time and variation in meteorological conditions. Spot checking for specific compounds under favorable meteorological conditions will play its part. In some cases, the culprit compound sought may result from a chemical reaction taking place in the air. The work of Haagen-Smit[17] and Blacet[18] at Los Angeles has indicated that the compound causing plant damage and acting as a lachrymator in Los Angeles was of this nature. Apparently, unsaturated hydrocarbons (such as are found in gasoline) may be oxidized to organic peroxides by sunlight in the presence of nitrogen oxide as a catalyst. Plant damage and lachrymators have been produced synthetically in plastic chambers under the same conditions and with the concentrations of these compounds which are present in the Los Angeles atmosphere. It may well be that organic peroxides formed under these same conditions are responsible for a part of the air pollution in some of our eastern cities.

Research along this line should be made a part of any metropolitan program.

Concentration of the Contaminant

CONSIDERABLE progress has been made when the compounds responsible for the air pollution and their source or sources have been identified. It will be necessary, then, to know the variations in concentration in the community from day to night, and with various meteorological conditions. This information should then be correlated with the amount of the contaminant being discharged into the air, the meteorological conditions, and the contaminant concentration which is found to be objectionable to the community.

Sampling methods and analytical methods have been described for most of the contaminants encountered in industrial atmospheres.[6,7] Knowing the nature of the contaminant, its approximate concentration, and particle size, suitable sampling and analytical methods may be selected.[4,5]

Reducing Contaminant Level

HAVING identified the contaminant or contaminants and their sources, the level of air pollution in the community can be reduced only by studying each plant individually. The most economical method for reducing the contaminant level will be different for different plants, depending upon many details.

In some cases, the contaminant will be separated from the effluent gases and dis-

posed of as a separate operation. There are many methods for this purpose:[21,22] liquid washers, mechanical and centrifugal separators, both wet and dry, baghouses, and other filtration units, agglomerators, adsorption units, incineration units of various kinds, electrostatic precipitators, tall chimneys, and others. Among the most recent are special filter paper for very fine particles, steam condensation to increase the effective size of fine particles, and high-temperature baghouses. In many cases, research work has found a commercial use for the material separated.

When the conventional methods of reducing the contaminant concentration are costly, or do not give a satisfying result, it even may be necessary to find a new method for manufacturing the product which will not contaminate the atmosphere. The result of many such programs is a more economical process, especially when the cost of preventing air pollution is included. Each plant presents a different set of conditions and must be studied individually to determine the most economical method.

Community Phase of the Problem

CAN a community legislate clean air? Obviously, the answer is no. Passing a law alone will never produce clean air. Only by the cooperative efforts of industry, local government, and the community at large, can a reduction in contaminant concentration be obtained. Each segment must do its part. Both the citizens and industry must give the air-pollution-control officials their enthusiastic cooperation to make the program a success.

In carrying out a program to clean up the air, the public-relations portion of the program is very important. The public should be told what is being done by industry to improve conditions, and how much it is costing. This will help convince the individuals of the importance of carrying out their part in the cleaner-air program.

Who pays for cleaning the air? It is evident that the public really pays for the cleaner air by paying higher prices. For this reason, the public has an interest in the efficiency of the cleaning system, and should not insist on unrealistic standards for industrial areas.

Maintaining Cleaner Air Standards

FOR MANY years, the air has been able to handle the unwanted constituents of our industrial era. It is quite evident that the concentration of industry in certain areas and the development of new industries have brought about conditions under which the air is not able to disperse these airborne contaminants satisfactorily. Steps must be taken to correct this condition. The excellent work of the MCA Air Pollution Abatement Committee is a recognition of this fact.

An important phase of future process development will be a study of the contaminant concentrations in the effluent gases and their dispersion in the air. In evaluating and comparing new processes, the cost of cleaning or purifying the effluent gases should be considered as part of the operating cost of each process.

In selecting new plant locations, consideration must be given to the handling of effluent gases to prevent air pollution in the community. This will include a study of the topography of the plant site and the meteorological conditions prevailing during various seasons of the year. Techniques for these studies are available. The far-sighted industry will take advantage of them to minimize this type of trouble in the future.

Summary

COMPLEX air pollution problems are usually associated with population centers. Air pollution affects the health, comfort, or use of property. To reduce air pollution, it is necessary to identify the contaminants and their sources, determine their concentrations, and study individual plants for economical methods of reducing the contaminant concentration.

Equipment and methods are available for measuring some contaminant concentrations continuously and all contaminants by short-time sampling procedures. Directional samplers indicate the wind direction when contaminants are collected. Kite-balloons make possible studies in the lower atmosphere. After the contaminants and sources have been identified, each individual plant must be studied to determine the most economical method for reducing the contaminant concentration. Many methods

are available. If none is satisfactory, a newly developed process may be the economical answer.

Cleaner air will result only from cooperative community effort. Since the public pays for clean air, it must be realistic about the standards maintained in industrial areas. In planning new processes and plants, the farsighted company will consider air pollution and use modern techniques available for studying this problem.

Bibliography

1. HEWSON, E. WENDELL, and GILL, GERALD C.: U.S. Bureau of Mines Bulletin 453.

2. SCHRENK, H. H., HEIMANN, HARRY, CLAYTON, GEORGE P., GAFAFER, W. M., WEXLER, HARRY: "Air Pollution in Donora, Pa." U.S. Public Health Bulletin No. 306, 1949.

3. LARSON, GORDON P.: "Recent Identification of Atmospheric Contaminants in the Los Angeles Basin." Air Pollution and Smoke Prevention Association of America Annual Meeting, 1951. Los Angeles County Air Pollution Control District, Annual Report (1950).

4. MUNGER, H. P.: "Spectrum of Particle Size and Its Relation to Air Pollution." First U.S. Technical Conference on Air Pollution, Washington, D.C. (1950).

5. SILVERMAN, LESLIE: Proceedings of First National Air Pollution Symposium, p. 55 (1949).

6. Test Procedures and Methods in Air Pollution Control. Published by Air Pollution Control District, County of Los Angeles, California.

7. JACOBS, MORRIS B.: Analytical Chemistry of Industrial Poisons, "Hazards and Solvents." Interscience Publishers, Inc., New York (1949).

8. "Atmospheric Pollution in Leicester: A Scientific Survey." Air Pollution Research, Technical Paper No. 1, London, England (1945).

9. MUNGER, H. P.: "Meteorological Methods for Studying Air Pollution." Presented at the XIIth International Congress of Pure and Applied Chemistry, New York, September, 1951.

10. MUNGER, H. P.: "The Engineering Approach to Cleaner Air for the Community." Presented at The American Public Health Association, San Francisco, California, November 2, 1951.

11. DAVIDSON, W. F., and MASTERS, WARREN: Monthly Weather Review, 69:257 (September, 1941); 70:225 (October, 1942).

12. HEMEON, W. C. L.: "Automatic Instruments for Air Pollution Measurements." Presented at the Roanoke, Va., Meeting, Air Pollution and Smoke Prevention Association, May, 1951. CHANEY, A. L., and HALL, STANLEY R.: "Instrumentation for the Recording of Air Pollution Levels." Presented at the Roanoke, Va., Meeting. Air Pollution and Smoke Prevention Association, May, 1951.

13. Second Interim Report (1949), Third Interim Report (1950): "The Smog Problem in Los Angeles County." Stanford Research Institute.

14. THOMAS, M. D., IVIE, S. O., and FITT, T. C.: "Automatic Apparatus for Determination of Small Concentrations of Sulphur Dioxide in Air." *Industrial and Engineering Chemistry, Analytical Edition*, 18:383 (1946).

15. WASHBURN, H. W.: Proceedings of the First National Air Pollution Symposium, p. 69 (1949).

16. PETTIT, A. B.: *Chemical Engineering*, 58:250 (1951).

17. HAAGEN-SMIT, A. J.: "Chemistry and Physiology of Los Angeles Smog." Presented at the XIIth International Congress of Pure and Applied Chemistry, New York, New York, September 13, 1951.

18. BLACET, F. E.: "Photochemistry in the Lower Atmosphere." Presented at the XIIth International Congress of Pure and Applied Chemistry, September, 1951.

19. JOHNSTONE, H. F.: *Indust. Med. & Surg.*, 19:107 (1950).

20. MUNGER, H. P.: "Techniques for the Study of Air Pollution at Low Altitudes." *Chemical Engineering Progress*, 47:436 (1951).

21. WELCH, H. V.: Metals Trans. AIME, 185:934 (1949).

22. "Clean Air—The Engineer's Way." Reprints from *Power*, July, 1947, to January, 1950 (14 articles in one reprint).

23. HARRIS, W. B., and LEVINE, H. D.: "Some Techniques and Equipment for Trace Quantity Sampling of Industrial Aerosols." U.S. Atomic Energy Commission, NYO 1534.

24. Private communication, GEORGE CLAYTON, U.S. Public Health Service, Cincinnati, Ohio.

The Development of Industrial Hygiene and Safety

LEONARD GREENBURG, M.D.

IN THIS AGE, we are often prone to pursue our specialized activity and remain somewhat oblivious to the wider stream of our field which does not happen to be our primary concern. On this occasion, it might be interesting to view the broader stream of industrial hygiene to see from whence it came and to think of how we can help it to go forward from here.

Leonard Greenburg

Whether or not they realized it, the people of England in the period from 1750 to 1800 witnessed the start of an era of vast industrial, social, and economic importance. For in that short span of years, the foundation was laid which changed England, and later much of the world, from a civilization of primitive handicrafts to that of a modern industrial civilization.

The primitive occupations of man were essentially the same as those seen today in a few of the remaining remote areas of the world—agriculture, fishing, and mining, occupations which could tap readily available sources of materials. These primitive occupations were, over a period of time and to an increasing extent, supplanted by a system of domestic industry or homework. In many rural homes in Britain, spinning and weaving were carried on side by side by all or most of the members of the family. The spinning of yarn was a slow operation compared with weaving and, to a great extent, served to limit the output of finished cloth.

In the year 1733, Kay invented the flying shuttle—a device for propelling the bobbin through the warp. Weaving could now be accomplished by one worker who now was not compelled to move from one position in front of the loom. This development increased the speed of the weaving operation and served further to dislocate the production relationship between weaving and spinning. By the year 1760, the flying shuttle was in wide use and the pressure for the improvement of the spinning process became strong. This need was met by the invention of the spinning jenny by Hargraves in 1765.

These two inventions, coupled with the use of water power, made it possible for large mills to be set up. In a short period of time much capital began to flow into the textile trade and the rewards in the new industry began of success to mount. These new and larger mills were built in those areas where streams for water power were available. Such places were, in many instances, in the remote and unsettled areas and, as a consequence, the problem of obtaining the mill hands became more and more acute. The parish authorities solved this problem by apprenticing the pauper children to the mill owners, thus relieving themselves of the care and support of the children and, at the same time, keeping the welfare taxes at a minimum. This appeared to be an excellent solution—but the apprentices, children from seven years of age and over, were badly treated and overworked, sometimes for 14 or 15 hours day and night. The housing conditions were bad, and no attention was given to the education, morals, or religious training of the children.

New inventions served to give further impetus to industry and particularly the cotton industry, for, in 1781, Watt perfected the steam engine; in 1785, Cartwright perfected the power loom; and, to satisfy the now present demand for raw cotton, Eli Whitney invented the cotton gin in 1793.

The industrial revolution was well launched and on its way.

The introduction of steam power in the cotton industry progressed rapidly in the period 1789-1792 and made it possible to locate factories at a point removed from

---

CUMMINGS MEMORIAL ADDRESS, delivered at Annual Conference of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION at Cincinnati, Ohio, April 22, 1952.

sources of water power, and thus they could be set up in towns nearer the sources of labor supply and the ultimate sales markets. There began an increased flow of population from the country to the larger towns. Factories could be increased in size and capacity, and vast sums were expended in new and enlarged factory construction. Young children, male and female, worked long hours in this new industrial plant. According to the record, children, even as young as six or seven years of age, worked for periods of 13 and 14 hours each day.

The increased density of population and the unsanitary living and working conditions led to the spread of epidemic disease which caused widespread alarm among the population of the mill towns in Manchester. As a result of an extended inquiry, Sir Robert Peel introduced a bill in Parliament which was enacted into law in 1802, and became known as the "Health and Morals of Apprentices Act."

This is the earliest example of wide-scope state intervention in private enterprise. For this reason, the Act is of marked significance.

The Act applied to all mills and factories employing apprentices and also to the mills and factories employing 20 or more other persons (not apprentices) at one time. It was designed to limit work to 12 hours per day and prohibited night work between the hours of 9:00 P.M. and 6:00 A.M. Some elementary provisions were made for welfare, education, and religious instruction. The walls and ceilings of all establishments were to be washed twice each year, and windows were to be sufficient to provide adequate ventilation.

The legal authority for the administration of this law reposed in the hands of the magistrates who were empowered to appoint two persons, one a justice, and the second a clergyman, to act as factory visitors.

It is not surprising that the Act of 1802 failed to achieve significant results. The factories were located in remote areas and this, coupled with a system of inspection manned by unpaid inexperienced persons, could hardly be expected to yield even a moderate degree of enforcement.

The introduction of steam power in 1806 served as an impetus to the enlargement of the mills. This was achieved by the investment of large sums of money in the new factories, and, in turn, resulted in increased pressure on the labor force for greater productivity. The attendant hardships, poor working conditions, long hours of labor both night and day, and the unsuccessful operation of the Act of 1802 led to the passage of laws in 1819, 1825, 1831 and 1833.

The Act of 1833 was limited in scope, for it only fully protected children and young workers employed in the cotton, woolen, worsted, and linen mills. There were provisions for the limitation of hours of work, both night and day. School attendance was required, and inspectors could establish schools where these were nonexistent or not of satisfactory quality. In the latter case, they could disallow salaries of teachers if the latter were found to be unsatisfactory. Inspectors were, by law, provided with the right of entry, and could also take testimony under oath. That is, they had the authority of magistrates. Four inspectors were appointed, and they were empowered to make rules and to supervise the registers of children. They could employ superintendents to assist them in their work, and they were obliged to keep minutes of their factory visits. The salaries of inspectors was fixed at £1000 per annum, but they were required to pay their own travel and hotel expenses.

The Act of 1833 represented real progress in the field of labor legislation but, as was to be expected, difficulties again arose in the administration of the Act. By shortening the hours of work for children, it became difficult to integrate their work with that of the adults who were working longer hours. A resort to shifts was attempted, but this was met with great difficulty and the inspectors themselves became convinced that something should be done to make an integrated work day possible. There was also great resistance to the wide powers of the inspectors, who by now were considered to have executive, legislative, and judicial powers. Finally, the problem of the education of children still remained unsolved.

Bills were again introduced in 1838 and 1839, but these failed of passage. Finally

in 1844, after many hearings and investigations, the Act introduced earlier in the year became law.

The Act of 1844 reduced the hours of employment of children to six and a half per day. Each child was required to possess a surgical certificate wherein the surgeon was required to certify that the child was not incapacitated by disease and, also, his belief that the stated age was correct. The factory inspectors were empowered to appoint the certifying surgeons and to issue regulations concerning their work and the districts in which they would be engaged. Every factory was to be registered within one month of its occupancy, and a copy of the factory act was to be posted in every factory. Every child was required to attend school for one half day, and such attendance was to be certified by the school master. A central office was organized for the factory inspectorate, and provisions were made for appointment of the necessary clerical and other assistance.

"The Act of 1802 established the principle of state intervention in the relationship between employer and employee. The Act of 1833 was significant because it marks the inception of a closely-knit centralized system of control, which, while it did not function very well, at least afforded a real opportunity for experiment on a large scale. The Act of 1844 succeeded in setting up an administrative system which was, in time, to serve as the nucleus for a central system of administrative control."

That the industrial revolution grew rapidly can be appreciated from the fact that in 1815 there were five million spindles in operation, while in 1835, the number had increased to 11.1 million.

Safety and Health Protection

EACH of the Acts previously referred to contained some provisions for health and safety—in the Act of 1802, these were very rudimentary, i.e., a provision that there be sufficient windows to secure adequate ventilation; this, of course, achieved little in the way of results.

In the Bill proposed by Lord Ashley in 1833, there was a provision that if an operator was killed and there was negligence in fencing in the machinery, the millowner responsible was to be committed for trial on a charge of manslaughter. For a non-fatal accident, the penalty could be from £50 to £200. These proposed provisions were removed from the bill prior to enactment.

The deliberations of the Parliamentary Commission considering the operation of the Act of 1833, made the first detailed proposals for safety in industry as follows: "The cleaning of machinery in motion, it was recommended, should be prohibited under the severest penalties. The dangerous parts of the machinery should be boxed off—upright shafts to a point seven feet above the floor, while horizontal shafts revolving within seven feet of the floor should be totally enclosed if the operatives passed beneath them. Those pulleys on the main shafting which revolved in passages or gangways should also be boxed within seven feet of the floor. In cases of accidents due to the machinery's being negligently left uncovered, some speedy and cheap method of recovering compensation should be devised."

When it came time to draft the Act, there was much discussion as to whether the inspector was to have discretion or whether the specific requirements were to be written in detail of the Act. It was decided to obtain more evidence on this point, but in the meantime, it was agreed that all accidents were to be reported and that these were to be further investigated by the certifying surgeons.

In 1833, the certifying surgeons were called in only for the purpose of certifying to the age of children working in the mills. Gradually, their function was extended—for they were required to vouch for the physical fitness of the younger workers and, also, to investigate accidents. Finally, when the time arrived that they were appointed by the inspectors, the surgeons had become a definite part of the industrial picture.

At this time (1843) one development took place which should be recorded here, namely, recognition of the need for the supervision of the health of the workers by a physician.

One mill employing more than 800 hands developed a plan for the certifying surgeon to serve as medical attendant. He spent the hours from 12:00 P.M. to 1:00 P.M. daily at the plant Surgery and

visited the homes of the sick, if the need arose. This is one of the earliest records of the employment of a physician by industry. That there were human sides to this picture may be appreciated, from the following quotation: "At this mill, there was also an excellent school, a savings bank, and a brass band of twenty-four instrumentalists. A fire escape was also provided. 'The knowledge of there being such an escape at hand would frequently encourage men to work effectually in the extinguishing of an incipient fire, instead of hurrying away in alarm on the first outcry to save themselves. To prevent this sort of confusion on such occasions,' said the owners, 'we have organized a species of "Fire Brigade," consisting of a few steady hands from each room who practice together monthly with the various water pipes, taps, hoses, buckets, etc., with which each room is provided, so as to be expert and steady if called upon to act'."*

The British Factory Inspectorate of today represents the natural growth of the fundamental program previously described. It now had jurisdiction over accident and industrial disease control as well as the hours of employment, canteens and feeding arrangements, and a safety, health and welfare museum.

Developments in America

INDUSTRY in America did not lag far behind industry in England; in fact Yankee ingenuity was very active in the new republic. In 1791, Sam Slater put up a spinning mill in operation in Rhode Island, and the development of the steamboat in 1787, the cotton gin by Eli Whitney in 1793, the cast iron moldboard for plows in 1797, and the automatic reaper in 1833, served to make the Union a busy and prosperous place. In 1807, there were only 15 cotton mills in the United States with 8000 spindles. In 1811, there were 80,000 spindles and in 1815, there were 500,000 spindles at work turning out the cotton thread necessary for the growing republic.

Industrial accidents, their resulting injuries and oftentimes death, became a mounting social and economic problem of importance.

*Horner's Report, 31st October, 1845. Parl. Papers (1846) XX, pp. 574-577.

The development of labor legislation in America followed the pattern in England. At first, laws were enacted for the protection of women and children, i.e., for the regulation of the hours of work and night work. Following this, the state legislature usually authorized the establishment of a bureau of labor statistics, to conduct studies on the type of administrative organization required, and then, finally, the establishment of a Division or Department of Labor with a staff of factory inspectors. Labor legislation in the State of Massachusetts became effective in 1836 with certain regulations concerning the employment of children, and regulations concerning accident prevention were enacted shortly after this. In 1879, Factory Inspection was legally enacted. Six years after this date (1885), safety requirements were enacted in New York State and factory inspection was instituted.

The U.S. Department of Labor took an active hand in bringing the European experience to America, and at the turn of the century, began publishing reports on accident prevention and statistics.

Heavy industry also recognized the importance of accident prevention, and thus the development of organized voluntary safety work in America began about 1900. In fact, some of the steel companies started work in the field in a limited way prior to that date. In 1901, the U.S. Steel Corporation was formed. This resulted in the development of a central safety committee in 1908. By 1910, the safety program of the U.S. Steel Corporation was well launched. One other large corporation had been doing excellent work in the field during this time, namely, the International Harvester Company.

Considering the magnitude of the problem as a whole, however, much still remained to be done, for, as industrialization increased, the number of accidents and the attendant social hardship continued to increase.

A study of industrial accidents in Alleghany County, Pennsylvania, made its appearance in a volume entitled "Work Accidents and the Law," written by Crystal Eastman, Secretary of the New York State Employer's Liability Commission. This served to attract wide notice to the

problem, and, with the general feeling of dissatisfaction with the adjudication of common law accident suits, led to more and more pressure for the passage of Workmen's Compensation Acts. As a result, beginning in the period 1911 to 1914, many states enacted such legislation.

The voluntary accident prevention movement led to the formation of the Association of Iron and Steel Electrical Engineers in 1912. This, in 1915, led to the formal organization of the National Safety Council, the largest and most important voluntary organization in the accident prevention movement in America.

Control of Health Hazards

DURING this period of development of labor protection and industrial safety, the protection against occupational health hazards received little attention from the official agencies; true, some of the acts spoke in general terms of adequate ventilation and noxious fumes, but nothing significant was accomplished. The study of this transition period of Industrial Hygiene is exceedingly interesting. A review of the publications of this period, and particularly those of the Department of the Federal government, serves as a guide to the official interest in these problems.

Probably as a natural result of its interest in industrial accidents and their prevention, the U.S. Department of Labor began to deal with the subject of occupational poisons. This Department published its first Bulletin on Industrial Hygiene in the year 1902—"A Report of the French Bureau of Labor regarding Industrial Hygiene." This was followed by a Bulletin on Factory Sanitation and Labor Protection in 1903, but most important was the publication in 1908 of a bulletin entitled "Industrial Hygiene," by Dr. George M. Kober, wherein the importance of dust in the causation of pulmonary disease was emphasized. This bulletin refers to studies of the State Board of Health of Massachusetts on the sanitary conditions of factories and work-shops, dated 1907. And reference is also made to the problem of dust in brass foundries, sand blasting, and the crushing, grinding and sifting of emery and corundum. The latter portion of this pamphlet is devoted to a consideration of the effects of poisonous gases and vapors. Finally, and probably as a lesson to Americans, the regulation of dangerous trades in England as set forth in the Factory and Work-Shops Act of 1901 is presented in full.

It was shortly after this that Dr. Alice Hamilton began her affiliation with the U.S. Department of Labor which was to result in the pioneering work about which you know and for which society will ever be in her debt.

The U.S. Public Health Service did not take an active interest in the field of Industrial Hygiene until the year 1912, when the Division of Industrial Hygiene was created and placed in charge of Dr. J. Schereschewsky. The first bulletin published by the U.S. Public Health Service relating to industrial hygiene, was entitled "Studies in Vocational Diseases," and was dated May 1915.

The U.S. Bureau of Mines was organized in the year 1910 and its first publications were not issued until after that time.

The first American textbook of importance on the occupational diseases was that of Dr. W. Gilman Thompson, Professor of Medicine at Cornell Medical College, entitled "The Occupational Diseases," published in 1914. In this same year, Dr. George M. Price's book, entitled "The Modern Factory," was published. The latter was not devoted alone to a discussion of the occupational diseases but also stressed problems of factory sanitation and factory inspection. Then, in 1916, Kober and Hanson published their well-known text, entitled "Diseases of Occupational and Vocational Hygiene."

The Dusty Trades

THE early history of the dusty trades is really the story of the mining industry. This took a course somewhat separate from that of the weaving and machine industries, for mining was a primitive industry and in wide practice by the time Agricola had published his now well-known volume entitled "De Re Metallica."

Disabling pulmonary disease was produced in mining operations and was known as long ago as the year 1550 and probably before that time. Serious study of the problem in England dates from the year

1862 when a Royal Commission began a study among metal miners.

The introduction of modern percussion drills about the year 1865, while decreasing the manual exertion required of the miner, also increased the dust content of the atmosphere. By the year 1905, the Cornish mine rules required that water be used in hand drilling operations and in power or compressed air drilling operations, the use of water jets or sprays was mandatory.

Inquiries were also begun in Australia and New Zealand in the early 1900's, but the most far-reaching investigations were those of the South Africans.

The most important dusty trade in South Africa is gold mining. This is carried on for the most part in the region known as the Transvaal where some 300,000 workers are employed in the deep underground operations of the Rand mines. The formation is one of high quartz content, and, for many years, no dust suppression measures were employed.

Here, the first inquiry was begun in 1902 "To ascertain the cause of the disease, and to make recommendations as to the preventive and curative measures which should be adopted." The first report published in 1903 was followed by a second report in 1910, and a third in 1912. But the most important report was that of March 1916, called the "General Report of the Miners Phthisis Prevention Committee."

This report was prepared by a large committee appointed: "To inquire into by experimental or other investigation and to report from time to time upon the improvement of the methods for the prevention of miners' phthisis in the Witwatersrand gold mines, and to advise upon the introduction of a systematic and uniform policy and the amendments to the Mining Regulations which may be necessary for combating the disease."

This General Report and its 1919 supplement, called "The Final Report of the Miners' Phthisis Prevention Committee," really constitute the foundation on which the American studies in the dusty trades, and particularly in the mining industries, rest. Here for the first time, the pooled knowledge of the South African workers was published.

The papers of McCrae, Watkins-Pitchford and Moir relating to the sizes of dust particles found in the ash of silicotic lungs provided convincing evidence that particles over 10 microns in size were of negligible importance, and henceforth need not be given consideration in the study of the problem.

The report also discusses the sampling and determination of dust, the principal operations giving rise to dust, the methods of preventing the formation of dust, the most suitable methods of preventing dust dispersion, as well as the pathology of the disease.

The sugar-tube method was recognized as the method of choice for the sampling of dust in the air in the 1916 report, but the final report, dated January 10, 1919, for the first time describes the Konimeter invented by Dr. Kotzé, the Chairman of the Committee. This, as you will recall, is an impingement method in which a spot sample of the mine air, about 10 cc., is impinged on a coated glass slide where the dust is deposited and then later counted under the microscope.

In the United States, prior to 1915, there were but one or two field investigations on the dust problem and these were concerned with the dust of the air of schoolrooms and that of the New York City subways. Ventilation was then going through a period of critical examination, and from the studies in New York City Schools by Winslow and Palmer, the dust sampling instrument of Palmer emerged.

Late in the year 1914, the Jasper County (Missouri) anti-tuberculosis league petitioned the U.S. Public Health Service to make a study of tuberculosis in that county. Dr. A. J. Lanza, well-known to all of you, and then an officer of the U.S. Public Health Service engaged in tuberculosis work, was detailed to make the study in Jasper County. He soon realized that he was not seeing uncomplicated tuberculosis but rather an altered form of the disease. This led to the publication of the first paper on the Joplin, Missouri dust problem in 1915. To the best of my knowledge, this is the first clear-cut industry study of the dust problem in the United States.

As noted earlier, the general Report of the Miners' Phthisis Prevention Commit-

tee made its appearance in 1916. Without question, this served as a stimulus and guide for American work from that time on. In 1917, two additional Joplin studies were published, one by the U.S. Bureau of Mines and one by the U.S. Public Health Service.

Reference was made earlier to the publications of the U.S. Department of Labor on the accidents, and to the Labor Department Bulletin of Dr. Kober in 1908 dealing with the dust problem. The Labor Department continued its interest in the dusty trades and in June 1918, Bulletin No. 231, entitled "Mortality for Respiratory Diseases in Dusty Trades" (inorganic dusts), was released. Frederick L. Hoffman, Statistician of the Prudential Insurance Company, the author of this pamphlet, a most unusual and interesting personality, in the introduction said: "The statistical evidence that certain trades or occupations are distinctly more unfavorable to health and longevity than others is so entirely conclusive that no additional proof seems to be necessary to reemphasize the earlier conviction that the state regulation of industry with special reference to the dusty trades and tuberculosis is a national and state labor problem of the first order in practical importance, yet there continues to prevail a lamentable degree of apathy and indifference to the urgency of necessary changes and reforms."

Dr. Hoffman's pamphlet, more than 400 pages in length, was only second in importance to the South African Reports. It is true that often it was not too critical of the material presented, but it was so encyclopedic in scope that it provided a rich source of basic data of a statistical nature.

Dr. A. J. Lanza, of the U.S. Public Health Service, and Dr. C.-E. A. Winslow, of Yale University, with whom I began my association in April of 1918, evinced continued interest in the dust problem so that small but suggestive studies were published by the Public Health Service each year.

At this time, the important professional organization embracing industrial hygiene, was the American Public Health Association, which had organized its Industrial Hygiene Section in 1915; fortunately too, it was that in May, 1919, the *Journal of Industrial Hygiene* made its appearance. During its first year of publication, abstracts of 11 papers on the subject of dust appeared in the abstract section.

If Leroy Gardner did not develop a deep interest in the dust problem, it would have been unnatural, for the setting was perfect for a man with his scientific and intellectual curiosity. Beginning in 1922, he put the resources of the Saranac Laboratory into dust investigations, and over a period of many years provided a continuous flow of valuable laboratory and field investigations.

It was at the Saranac Laboratory, in association with Dr. Gardner, that Donald Cummings, the man whom we memorialize this evening, worked on the problems of the dusty industries. Don Cummings was a young man of extraordinary energy and vitality. He possessed what athletes usually refer to as "bounce" to a marked degree. His capacity for work seemed unlimited. This, with his clarity of mind and his knowledge of many fields, made him an able teacher. Undoubtedly, his most outwardly striking characteristic was his personal charm which made him a most congenial companion and warm human being. It was these qualities which helped to make the Gardner-Cummings team a symbiotic one which resulted in developing both the laboratory and field work of the Saranac Laboratory to a place of eminence in the world of research. The passing of Don Cummings has created a void which will take long to fill.

The problem of appraising the degree of hazard of the dusty environment developed into extensive studies and eventuated in a joint study by the Bureau of Mines and the U.S. Public Health Service in the summer of 1922. From this emerged the development of the impinger dust sampling instrument. With all its shortcomings, it has served as a useful tool.

A discussion of this period of the story of dust investigations would not be complete without reference to some later work of the Public Health Service in the dusty trades. These studies in the cement, granite, coal mining and textile industries yielded data of an epidemiological character which made it possible, along with other data, to arrive at standards which, after a time, formed the basis of quantitative al-

lowable limits for certain dusty occupations.

From the American studies made in the dusty trades as well as in other occupations, it is clear that among the most important of the fundamental American contributions to industrial hygiene, may be mentioned the following:

1. Epidemiological type studies relating both the quantitative and qualitative nature of the exposure to the health of the worker;
2. Instrumentation with which it became possible to quantitate the contaminants;
3. The development of standards based on the quantitative dust studies and the epidemiological findings. These standards have often been referred to as bench marks and maximum allowable concentrations, and;
4. The preparation of codes and regulations based on the judicious use of such standards.

The Administrator in the official industrial hygiene agency is in a position, because of his wide contacts with industry, labor, insurance companies and industrial hygienists, to appraise the work of these agencies in the field. After 15 years in such a position, certain convictions concerning the relative strength and weaknesses of our approach and certain hopes for the future emerge. They are presented for whatever they may be worth.

Official Agencies

THE FIELD of activity of the official agency is broad and varied. Problems arise not only in industry, but also in mining and agriculture. Areas of jurisdiction are large, covering, in most instances, whole states. Distances are great. In order to do a good job, large staffs are required, and budgets tend to run high. We in the field think that salaries are too low to attract men who have spent the necessary years in training, but our budgets are always considered too high in the mind of the budget director.

Without question, staffs are inadequate for the problem. This is particularly true of medical staffs. For now, we are in competition with the armed services and private practice, as well as public health, for the services of doctors. Specifically, the official agencies lack funds for personnel, travel and research.

Health Education of Workers

OUR weakness in this portion of the field is self-evident. The National Safety Council has contributed much to safety education, and perhaps this might be used as an example in an effort to develop health education among workers. The voluntary health agencies have not taken an active interest in worker health education. It would seem wise for them to give this problem serious consideration in this time of changing approaches to the problem of public health. The official agencies certainly lack funds for this purpose. Should not the unions themselves assist by helping to defray the cost by taking over a portion of this activity in their own areas of jurisdiction?

Teaching

FOR many years, few universities engaged in teaching in the field of industrial health. The work at Harvard in this field, beginning in 1918 or 1919, was forward-looking and has been fruitful and inspiring. Now many of our universities are doing a constructive job in the teaching of industrial health. The results are, to say the least, most encouraging.

History clarifies problems, and, from our knowledge of the past, we develop perspective, learn patience, and how to carry on in the future. Should not the teaching of the history of public health, industrial hygiene, and the development of labor legislation receive emphasis in our teaching institutions?

Is not industrial safety an important part of our field of activity? Where is the teaching of industrial safety in our American colleges and universities? It would seem that this is a neglected part of the field of industrial health. There is a demand for young properly-trained men in this field, and it would seem to be fitting for college graduates, with at least one year of specialization in safety work, to enter industry.

Most of our teaching institutions in the field of industrial hygiene give the students a certain amount of field experience, but would it not be better to put this on a more formal basis, so that, without question, each man would spend at least two months working on problems preferably with an official agency, in industry where

the problems are—on the "firing line," so to speak?

Publications

THE publications at our disposal in America are making a fine, constructive contribution. There is a seeming lack in our literature of the presentation of actual clinical cases of occupational diseases. One might speculate as to the reason for this. It would, without question, be helpful in the proper adjudication of compensation cases and the prevention of occupational diseases, if more clinical information were available. The British journals do this very well. This is not to be considered as a criticism of the journals but of the lack of such material sent in for publication.

Industry's Contribution

THE contributions of large industries have been tremendous. They have been doing a fine job in the field of research, hazard control, and the health of the industrial worker. The large number of industry representatives who are members of the Industrial Health Organizations is testimony to industry's very vital interest in this activity.

Many industrial organizations are liberal in their support of research, but much more could be done in the publishing of their findings, and in the extension of research projects.

The Small Plant

OUR most important remaining problem is the small plant. They employ the majority of the workers of our industries. For example, in New York State plants with fewer than 200 employees give employment to 60% of the industrial workers of the state, and plants with fewer than 500 employees provide work for 73% of the state's industrial workers.

A recent study not yet released, made by the Division of Research and Statistics of the Labor Department, in cooperation with the Division of Industrial Hygiene, serves to emphasize once again the lack of health provisions in plants of small size, but this lack is only a part of the picture, for, in most cases, these small plants usually lack provisions for the control of safety and of occupational disease hazards. They, too are more often the plants where sanitation is neglected and general housekeeping is poor. They need aid and guidance which they themselves cannot well afford.

Insurance Companies

SOME of the insurance companies have been very farsighted in attacking problems in industrial health and assisting their clients in the development of programs for safe practices, health protection, and rehabilitation. The insurance companies have a large financial stake in industrial health. They can make a tremendous contribution to this problem in many ways. It is hoped that more of the companies will embark on work in this field in the not too distant future.

Workers' Efficiency

THROUGHOUT this discussion and most discussions of industrial hygiene, the basic thought is the prevention of accident and disease. There is, however, one other part of the program which needs emphasis, and that is workers' efficiency.

Is it not time that we in America stressed the human performance and measures for its evaluation and maintenance? It would seem to the speaker that the British are far ahead of us in doing this.

It is likely that, today, we are at the beginning of what might be a second industrial revolution and we, like our predecessors of 1775, may not be fully aware of this.

The developments in the fields of atomic energy, electronic mechanisms, computing machines, automatic factories, and agricultural and chemical discoveries, may well lead to a type of industry which is far different from that existing at the present time. Certainly, industry will become more and more automatic. As this takes place, the worker will become more and more important, and his performance will undoubtedly hold greater significance for industry.

If this is true, we need more emphasis on industrial physiology and industrial psychology, and we should widen use of our knowledge of anatomy in plant and machine design.

Let no one say that the future is not

bright. We have come a long way since 1775, and a mighty task has been well done. There is every reason to believe that the future will continue to bring beneficial returns to mankind. In this effort, the industrial health specialist will, judging by recent performances, without doubt, continue to play a larger and more significant role in American industry and American life.

The Ten Commandments of Industrial Hygiene

1. Thou shalt work hard and earn thy salary.
2. Remember first the worker, as it is optimum health thou art seeking.
3. All phases of industrial hygiene shalt thou consider and work today as a part of thy plan for tomorrow.
4. Thou shalt not be biased.
5. Thou shalt not have any personal animosity over a professional difference.
6. Thou shalt not withhold information.
7. Thou shalt not take credit for that which is not thine.
8. Thou shalt be cooperative and helpful.
9. Thou shalt not seek personal publicity; fill not the literature with tripe.
10. Thou shalt not stagnate but shalt strive to add to the sum of human knowledge and to extend thine own knowledge.

—ANONYMOUS

INDUSTRIAL HEALTH
•
HYGIENE AND SAFETY SERVICE

6432 Cass Avenue, Detroit, Michigan
Trinity 1-4812

GORDON C. HARROLD, PH.D.
STUART F. MEEK, M.D.
AND ASSOCIATES

EMERSON VENABLE, P.E.
CHEMIST AND ENGINEER
Fellow, American Public Health Assoc.

CONSULTANT
IN
Air Pollution, Chemical Warfare and Industrial Hygiene—Research

PHONE HI-land 1-8045
6111 FIFTH AVENUE PITTSBURGH 32, PA.

INDUSTRIAL HYGIENE BRIEFS

Nitrogen Oxide Exposure

THE PRODUCTION of nitrogen oxides in the air surrounding the flame of an oxyacetylene torch is a phenomenon which although reported in the literature as early as 1928 has been given less prominence as a potential cause of disablement and death than it rightly deserves.

Fatalities resulting from exposure to nitrogen oxides generated by oxyacetylene torches are not unknown in the literature. In 1934, one death was reported in England.[1] A German death was reported in 1938.[2] A fatal incident was reported in the American literature in 1939.[3]

The account which follows is of an investigation into the constituents of the atmosphere in closed tanks (63 feet by 10½ feet in diameter) during and after oxyacetylene scarfing and burning within the tank. A torch (#6 tip) which consumed 468 cubic feet of acetylene and oxygen per hour was the only torch used.

The matter of ionization of the air, without which production of nitrogen oxides cannot take place is explained by the fact that both oxygen and nitrogen are ionized at the temperature of the oxyacetylene flame.[4]

In every case, samples were collected in the breathing zone of the burner or scarfer insofar as possible and never at a point more than three feet from the head level of the workman. Depending on the work, these collection points vary over a vertical distance of five feet indicating that the concentration of nitrogen oxides was well dispersed throughout the area.

Tests were made under several sets of circumstances, using the method described by Patty and Petty.[5] In the situation represented by the findings tabulated in Table I, two braces (4" by 4" angles) extending from one side of the tank to the other were cut out by means of an oxyacetylene torch. Table II gives the results of tests taken in a tank where scarfing of imperfections was being done. In Table III are shown results of tests made in a tank in which scarfing was being done, the tank being exhaust ventilated through a manhole (2½ feet in diameter) at the rate of 4,000 cfm, the point of exhaust being 40 feet distant from the burner. The results shown in Table IV are those of tests made in a tank during scarfing while air was being blown in the opposite end from that in which the scarfing was taking place at the rate of 400 cfm and exhausted at the rate of 4,000 cfm at a point 40 feet from the scarfing area.

TABLE I.
CUTTING BRACES

	Nitrogen Oxides in parts per million
After 10 minutes cutting braces	35 ppm.
After 15 minutes cutting braces	250 ppm.
After 25 minutes cutting braces	260 ppm.
After 30 minutes cutting braces	300 ppm.

> 200 ppm.

Note: Above results are chosen at random from a series of 16 tests all showing same order of magnitude.

TABLE II.
SCARFING

	Nitrogen Oxides in parts per million
After 5 minutes	8 ppm.
After 5 minutes	10 ppm.
After 10 minutes	35 ppm.
After 13 minutes	100 ppm.

TABLE III.
SCARFING WITH EXHAUST VENTILATION

	Nitrogen Oxides in parts per million
After 5 minutes	10 ppm.
After 10 minutes	50 ppm.
After 20 minutes	100 ppm.

TABLE IV.
SCARFING WITH SUPPLY AND EXHAUST VENTILATION

	Nitrogen Oxides in parts per million
After 5 minutes	8 ppm.
After 10 minutes	20 ppm.
After 15 minutes	35 ppm.
After 30 minutes	> 50 ppm.

[Contributions to this column are invited. Interesting industrial hygiene data, helpful hints, or solutions to engineering problems will be welcomed. Please send to Herbert T. Walworth, Lumbermens Mutual Casualty Company, 4750 Sheridan Road, Chicago 40, Illinois.]

Conclusions to be drawn from the foregoing are obvious. There is a real and present danger from the use of oxyacetylene torches in closed spaces when the burner or scarfer works without respiratory protection or ventilation. The large amounts of nitrogen oxides found under unventilated conditions seem to be out of balance with the short exposure period, but nevertheless were confirmed by duplicate tests.

References

1. Industrial Accidents 4, 1934. (H. M. Stationary Office, London).
2. Chemisches Zentralblad, 1:3497, 1938.
3. WRIGHT-SMITH, R. J.: *J.I.H.&T.* 21:24 (1939).
4. Communication, Director of Research & Engineering, Air Reduction Company.
5. PATTY, F. A., and PETTY, G. M.: *J.I.H.&T.* 25:361, 1943.

BOOKS

Dangerous Materials

HANDBOOK OF DANGEROUS MATERIALS: By N. IRVING SAX. Reinhold Publishing Corp. 330 West 42nd Street, New York 18, N. Y., 1951; pp. 848; $15.00.

THERE IS badly needed an authentic up-to-date reference on hazards to health from handling chemicals, written for the use of the physician, industrial hygienist, safety engineer, foreman and chemist. This handbook attempts to meet the need by listing an interpretation of the literature on 5000 chemical compounds. Flammability is included. Some 50 pages are devoted to storage and use of explosives, 60 pages to fungus diseases and fungicides, 70 pages to radiation hazards, and 120 pages are a reprint of the I.C.C. Regulations for Transportation of Explosives and other Dangerous Articles of Freight. Unfortunately the last named section is taken from Tariff No. 4 which was superseded in April, 1951 by Tariff No. 8 and hence was out of date when the handbook appeared.

The majority of the compounds are discussed in terms of the hazards of handling, using simple, reasonably uniform language. However, the entries for several hundred compounds merely report numerical results of experimental studies without interpretation in terms of practical hazards. These are no more useful to the man without extensive toxicological experience than would be photostats of the original research reports. The handbook badly needs a few pages of discussion of the principles of toxicology, and of the relation between toxicity, physical properties, plant operations and hazard to health.

Many of the original references have been misinterpreted, usually but not always in the direction of suggesting hazards greater than actually exist. This over exaggeration of hazard and necessary protection is most evident with regard to eye injury and skin irritation.

The handbook would not mislead the experienced toxicologist thoroughly familiar with the literature and industrial operations. It does not appear sufficiently accurate to recommend to others who are unable to weigh and check its statements.

—HENRY F. SMYTH, JR.

American Industrial Hygiene Association

— A Report of the Thirteenth Annual Meeting —

Cincinnati, Ohio

THE THIRTEENTH Annual Meeting of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION was held at the Netherland Plaza Hotel, Cincinnati, Ohio, April 22-24, 1952. A total of 478 members and guests registered for the meetings, setting another record for attendance. The Industrial Health Conference as a whole reported a total attendance of 1,832 for the technical sessions.

It is interesting to note the growth of AIHA over the past 10 years as demonstrated by the annual meeting attendance figures.

In 1942 the Conference was held in Cincinnati and 108 were registered. The attendance figures grew steadily until five years later (1947) in Buffalo, 262 were registered. The 478 figure this year is more than double the 1947 figure and an increase of 171 over 1951 when 307 were registered at the Atlantic City Meeting.

Field trips, the Local Sections Council luncheon and the Board of Directors meeting were held Monday, April 21.

One of the outstanding features of the AIHA meeting this year was the scheduling of concurrent sessions on Thursday, April 24 covering the specialties of Air Pollution, Chemical and Analytical Problems, Engineering, Radiation, and Toxicology. Heretofore all specialized technical papers were included in the general sessions. Judging by the excellent attendance at all concurrent sessions, this plan of program scheduling was successful.

The annual banquet was held at the Netherland Plaza Hotel at which the Donald E. Cummings Memorial Lecture was presented by DR. LEONARD GREENBURG. DR. GREENBURG presented a history of industrial hygiene, and emphasized the developments in the field.

The annual business meeting was held on April 24 when the results of the election of officers was announced. The new officers elected were: President, WILLIAM R. BRADLEY, The American Cyanamid Company; President-Elect, HENRY F. SMYTH, JR., PH.D., Mellon Institute; Treasurer, LESTER V. CRALLEY, PH.D., Aluminum Company of America.

Newly-elected members of the Board of Directors are: KARL L. DUNN, Corning Glass Works; FRANCIS R. HOLDEN, PH.D., U.S. Naval Radiological Defense Laboratory; KARL Z. MORGAN, PH.D., Oak Ridge National Laboratory; HERBERT J. WEBER, American Brake Shoe Company.

The 1953 Industrial Health Conference will be held at the new Statler Hotel in Los Angeles, California. AIHA sessions will be held April 21, 22 and 23. Undoubtedly field trips, Local Sections Council luncheon and meeting, and the Board of Directors dinner and meeting will be held April 20.

William R. Bradley succeeds Dr. Anna M. Baetjer of the Johns Hopkins School of Hygiene and Public Health as President of the Association. Mr. Bradley received his B.A. degree from Cornell College Mount Vernon, Iowa, in 1929. He received his M.S. degree from State University of Iowa Graduate College in 1933. He is past-president and past-secretary of both the Michigan and Metropolitan New York Sections of the American Industrial Hygiene Association. He is a charter member and has served on the Board of Directors of the AIHA; a member of the American Chemical Society; a Fellow of the American Association for the Advancement of Science; a member of the Committee on Chemistry and Toxicology, Industrial Hygiene Foundation of America, Inc.; a member of the Sub-Committee on Atmospheric and Industrial Health, National Research Council, Washington, D.C. He was Co-Chairman in 1951 of the AIHA Annual Meeting.

The President's Page

THE ANNUAL meeting of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION for 1952 again made history. We might pause for a moment to reflect on the many accomplishments of AIHA during the past years since the inception of this rather unique Association of scientists in the field of preventing occupational illness. Such a reflection would show at once that a group of very enthusiastic people, vitally interested in their work, comprise this Association. With such enthusiasm, the rewards of cooperative effort are to be expected, so if we take time to pause and reflect we are only indulging in patting ourselves and each other on the back.

From this group of people there are bound to come ideas. In fact, they are coming so rapidly that we do not have time to pause and reflect on what we have accomplished, unless it be to become aware of the path we are following in order to decide just where we are going.

Our new year has started in a rush of activity. In fact, it started in Cincinnati, following the sound of the gavel that closed our 1951-1952 year. Plans for the 1953 meeting in Los Angeles are already well under way as is the work of the newly constituted AIHA committees.

Association committee work is, on occasion, hard work and, in many instances, time consuming. But the wholehearted response of the membership comprising AIHA expressing their willingness to serve the Association in committee work is one of the certain signs of a progressive group. There no longer remains a question concerning industrial hygiene as a profession. It has emerged in its true light and full stature. Active committee work with careful leadership, guidance and sound deliberation have brought about a good part of this professional advancement.

Usually, the work of committees is unsung. There is merely the listing of their names in the Association journal. This applies only to the standing committees. Not usually listed or published are the names of the members of a large number of interim committees whose work is likewise equally important to that of the standing committees. In addition, there are those of our members who officially represent AIHA in the affairs of other related national associations. Space does not permit reciting the many valuable contributions rendered by the work of the interim committees, but does permit acknowledgment by publication of the following interim committees and representatives:

American Industrial Hygiene Association Quarterly: Herbert T. Walworth, Editor; William T. McCormick, Associate Editor; Howard Schulz, Circulation Editor; Vincent J. Castrop, Advertising Editor; John M. Kane, Associate Advertising Editor; Walter F. Scholtz, Associate Advertising Editor; Bernard D. Tebbens, Associate Advertising Editor; William F. Weber, Associate Advertising Editor.

Development Committee: Warren A. Cook, Chairman; William T. McCormick, Howard N. Schulz, Herbert T. Walworth, Herbert J. Weber. Consultants: Allen D. Brandt, Sc.D., and James H. Sterner, M.D.

Committee on Noise: Charles R. Williams, Ph.D., Chairman; Allen D. Brandt, Sc.D., Lester V. Cralley, Ph.D., Edward C. Meiter, Ph.D., Walter F. Scholtz, James H. Sterner, M.D., Herbert T. Walworth.

Committee on Professional Opportunities: Robert M. Brown, Chairman; C. M. Berry, Ph.D., J. B. Gisclard, W. B. Harris, F. R. Kahl, R.N., J. W. Meigs, M.D., H. H. Schrenk, Ph.D.

Sub-Committee on Scholarships (Education Committee): N. V. Hendricks, Chairman; Merril Eisenbud, T. F. Hatch, Norton Nelson, Ph.D., S. E. Miller.

Committee on Sectionalization (Independent Groups): Allen D. Brandt, Sc.D., Chairman; Edgar C. Barnes, T. F. Hatch, James H. Sterner, M.D.

Program Committee for AIHA-AAAS-Section P 1952 Meeting: Elmer P. Wheeler, Chairman; Knowlton J. Caplan, Louis F. Garber, Jerome E. Molos, R. A. Sutter, M.D. Ex-Officio: N. V. Hendricks, Secretary, Section P; F. A. Patty, AIHA representative to AAAS; H. F. Smyth, Jr., Ph.D., Executive Secretary, AIHA.

Program Committee for Joint AIHA-ASSE 1952 Meeting: Kenneth M. Morse, Chairman; Floyd Van Atta, Charles W. Wyman.

Representatives

Representatives to ASA Safety Code Correlating Committee: William P. Yant, Sc.D., with Warren A. Cook, alternate.

Representative to American Society for Testing Materials—50th Anniversary Meeting: Thomas W. Nale, M.D.

—WILLIAM R. BRADLEY

American Industrial Hygiene Association

Report of Temporary Committee on Lantern Slides

THE COMMITTEE has prepared the following suggestions for preparing legible lantern slides for use at AMERICAN INDUSTRIAL HYGIENE ASSOCIATION meetings.

1. A lantern slide is meant to aid the speaker in presenting a fact or an idea. *It should present only one central idea.* It does not need to be complete in itself and presupposes explanation by the speaker.

2. *Larger letters are necessary for lantern slide originals than for material intended for printing.* Therefore, it is best not to try to use material intended for books or reports, but to make special originals.

3. *The proportions are important.* An original of about eight inches high and 10 inches wide is usually satisfactory.

4. *The number of words on the slide should be kept at a minimum and never more than 20.* The space between words of a sentence should be about 1.0 to 1.5 times the height of the letters. The space between letters of a word or digits of a figure should be about two to three times the width of the line forming the letters or figures. Spaces between columns of figures should be at least three times the height of the digits. Spaces between horizontal rows of words or figures should be at least 1.0 to 1.5 times the height of letters or digits.

5. *Lettering should be in India Ink using a Template such as Leroy or Wrico.* Vertical Gothic capitals are preferred.

6. The minimum height of a capital letter in a 3¼ x 4 inch slide should not be less than $^1/_{16}$ inch. Some typical examples of the proper type of Leroy and Wrico Templates and pens (and the corresponding sizes and dimensions of originals to produce this minimum height) are given below. (Small variations from these sizes will not be detrimental.)

Size of Original for 3¼ x 4" Slide	Size of Original for 35 mm. Slide	Leroy Template	Leroy Pen	Wrico Guides	Wrico Pen
5½ x 6	4 x 6	120	00	200	6
8¼ x 9	6 x 9	175	1	290	4
11 x 12	8 x 12	240	2	290	4

7. If using a typewriter, use Pica type, and type in a total area no larger than 5½" in height by 6" in width for a 3¼" x 4" slide; or a 4" x 6" area for 35 mm. slides (often called 2 x 2" slides).

8. *In preparing graphs, try to limit the curves to three.* Make the curve line heaviest. They should be about twice the width of the coordinates and about four times the width of the grid lines. The curve should not pass through letters or data points.

9. *In preparing tables, use only such data as will actually be discussed.*

10. Color slides are ideal for illustrating complicated flow diagrams—overlapping curves—sector or bar diagrams, etc.

—DAVID W. FASSETT, M.D., Chairman
HENRY G. LAMB

References

1. Engineering and Scientific Charts for Lantern Slides: American Standards Association Publication, 15:1, 1947.

2. Guide to Speakers: American Institute of Chemical Engineers, 120 East 41st Street, New York 17, N. Y.

3. Preparation of Effective Lantern Slides: L. S. BONNELL (Esso Laboratories—Standard Oil Development Co., Elizabeth, N.J.). *Chemical Engineering News*, 27: 2600, September 12, 1949.

American Industrial Hygiene Association

— News of the Local Sections —

Chicago Section

AT THE MARCH 5 meeting of the Section, J. H. CARNAHAN, Director of First Aid, American Red Cross, discussed "Methods of Artificial Respiration With a Demonstration of the Newly Adopted 'Back-Pressure Arm-Lift' Method." MR. CARNAHAN explained the advantages of the new Holger-Nielsen method which now officially replaces the Schafer method of artificial respiration.

Due to illness, DR. JOSEPH A. HUBATA, Associate Medical Director of Armour Laboratories, was unable to deliver his paper, "The Use of New Drugs in the Industrial Medical Department." DR. CLIFFORD H. KALB, member of the American Academy of Allergists, spoke in lieu of DR. HUBATA. Slides of individual cases augmented DR. KALB'S discussion of dermatitis.

On April 2, DR. R. M. WATROUS, Plant Physician and Medical Editor, Abbott Laboratories, discussed "Health Hazards in the Fine Chemical Industry." DR. WATROUS outlined methods for meeting and overcoming the hazards which arise from the use of materials unique to the fine chemical industry, as well as from those materials which have a general widespread use.

Ohio Valley Section

ON TUESDAY, March 18, the Ohio Valley Section of the A.I.H.A. heard an address, "A Critical Review of the Industrial Hygiene Program in the State of Ohio," by DR. THOMAS F. MANCUSO, Chief, Industrial Hygiene Division, Ohio Department of Health.

Members of the Ohio Valley Section took an active part in organizing and planning the annual meeting of A.I.H.A. held in Cincinnati during the week of April 21.

Northeastern Ohio Section

THE NORTHEASTERN OHIO Section met March 24 at the Cleveland Engineering Society in joint dinner session with the Northern Ohio Chapter of the American Society of Safety Engineers.

The speaker for the evening was DR. CHARLES R. WILLIAMS of the Liberty Mutual Insurance Company of Boston. His subject was "The Relationship Between the Safety Program and Industrial Hygiene."

The Annual Meeting in May will be held at the Cleveland Graphite Bronze Company at which time election of officers will take place. At present, F. S. MALLETTE, American Steel & Wire Division, U.S. Steel Company, is Chairman; W. L. WILSON, Cleveland Bureau of Industrial Hygiene, is Vice Chairman; and K. A. KELSEN, Goodyear Tire & Rubber Company, is Secretary-Treasurer.

Northern California Section

THE Executive Committee met on March 11, before the regular meeting of the Section. The regular meeting was held at the Fly Trap, a well known restaurant in San Francisco.

DR. RAYMOND ALLINGTON discussed the "Diagnosis and Prevention of Industrial Dermatoses," presenting not only a discussion of the types of pathology resulting from general classes of skin trauma, but also of the proper use of patch testing and amplified his diagnostic criteria with some unusually illustrative Kodachromes.

Western New York Section

THE NINTH Annual Meeting of the Western New York Section was held in the Blue Room of the Westbrook Hotel, Buffalo, New York. At the morning session, Saturday, April 5, ALFRED HOFTIEZER, Safety Supervisor for Laverack and Haines, discussed "Industrial Hygiene in Small Plants—From the Viewpoint of the Safety Engineer."

DR. CHESTER SAMUELSON, Medical Director of Harrison Radiator Division of General Motors spoke on "Chemical Safety Control in a Small Plant—A Successful Program and How It Operates."

The morning session was concluded with the announcement of election results and installation of new officers.

HARRY FARKAS, Division of Industrial Hygiene, New York State Department of Labor, was the first speaker of the afternoon, opening the session with the topic, "Industrial Hygiene Problems of the Small Plant—From the Viewpoint of the Governmental Agency."

DR. MARVIN L. AMDUR, Blanchard Industrial Clinic, closed the session with his "Development and Direction of Small Plant Industrial Hygiene Problems."